TOWARD THE STANDARDIZATION OF USE-WEAR STUDIES:

CONSTRUCTING AN ANALOGUE TO PREHISTORIC HIDE WORK

A Thesis

by

JAMES EDWARD WIEDERHOLD

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF ARTS

May 2004

Major Subject: Anthropology

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Approved as to style and content by:

Harry J. Shafer (Chair of Committee)	D. Bruce Dickson (Member)
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ABSTRACT

Toward the Standardization of Use-Wear Studies: Constructing an Analogue

to Prehistoric Hide Work. (May 2004)

James Edward Weiderhold, B.S., Texas A&M University

Chair of Advisory Committee: Dr. Harry J. Shafer

This thesis is a use-wear study that deals with microwear on stone endscrapers used on one worked material: animal skins. The first part of the study defines and describes the process of rendering freshly skinned pelts into functional leather or rawhide products, addressing confusing terminology found in the literature as well. Problems with past use-wear experiments dealing with animal skins are also confronted and explained. The second part of the study examines endscrapers used to flesh and dehair bison hides and compares the use-wear traces left on the tool edge by each activity. This suite of characteristics is then compared to those found on an assemblage of Clovis-age scrapers from the Gault site in central Texas.

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Finally, I wish to express my love and heartful appreciation to my long-suffering wife and children, without whom, none of this would be possible, and to my father, Albert G. Wiederhold, who unknowingly sparked a young boy's interest in working hides "the hard way."

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CHAPTER I

INTRODUCTION

This thesis identifies and describes the necessary steps in aboriginal hide processing in an effort to standardize the functional analysis of endscrapers, and further, to determine whether these steps can be detected in the archaeological record. When we consider the wide variety of serviceable products potentially available in a freshly taken, or "green," hide or skin, we must conclude that the processing of animal hides and skins was undoubtedly an industry of paramount importance in the lives of native people of North America, perhaps second only to the manufacture of stone tools. Archaeologists have gained a great amount of technological knowledge of the past through studies of stone tool manufacture, especially through the *actualistic* work of individuals like Don Crabtree, Francois Bordes, J.B. Sollberger, and Errett Callahan. Their efforts, along with the efforts of many others like them, are largely responsible for providing us with first hand knowledge of how stone tools were made. Additionally, their work has generated a wealth of further studies, including not only description and classification, but also ecological and behavioral aspects of stone tool technology.

Similarly, data provided by the archaeological record and ethnographic accounts, enhanced by task-oriented experimentation, can provide knowledge of indigenous hide working methods. Understanding these methods and their resulting products would

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This thesis follows the style and format of *American Antiquity*.

allow us to expand our perception of the use of plant and animal resources, trade and other economic activities, seasonality, and climate. In addition, it would shed more light on how certain stone tools were used. Yet, useful as such information might be, the actual process by which a green hide or skin is changed into a useful product and the techniques or methods employed are not well known by archaeologists. No study that I am aware of describes the process in a comprehensive and unambiguous manner. The purpose of this thesis then is twofold. The first is to determine, describe and analyze indigenous methods of hide processing. The second is to conduct an experimental use-wear study to determine whether we can identify different steps of the process in the archaeological record. More specifically, this study will:

1. Define and describe the steps that must be included in any hide-working activity in order to transform a freshly taken hide into a functional product regardless of time, space, species, or method used. Based on these steps, a model of aboriginal hide processing will be constructed and used to identify and describe methods available to, and used by native peoples to accomplish the process.
2. Evaluate previous use-wear studies in light of the model and the described methods in order to resolve some of the contradictions and disputes they have generated, and clarify some of the confusion regarding hide processing in general.
3. Describe the features and characteristics of use-wear on replicated endscrapers generated by processing bison hides according to the above

model, and compare these data with previous use-wear studies and experimentation.

4. Determine whether different steps within a particular method and/or different methods of hide processing will result in different use-wear features and characteristics.
5. Determine whether such use-wear features and characteristics can be recognized in the archaeological record (a central Texas Paleo-Indian site).

The Study of Indigenous Hide Processing

I mentioned above that hide processing steps as well as various methods are not generally well known. There are several reasons that this is the case. First, one of the most obvious reasons is that the archaeological database is small in that hides and skins and the products made from them do not preserve well in the archaeological record. Secondly, hide products that are preserved are often very small pieces and badly weathered as well, making analysis difficult. There are, however, hide and skin products from the historic era in the form of clothing, parfleches, tipis and the like, that are housed in various museums across the country, but even so, it is difficult to identify how these products were manufactured if the methods and techniques are not known. Comparing the study of hide processing to the study of the manufacture of stone tools, it would be hard to visualize the emergence of a projectile point from a lump of chert without knowing anything about the fractal properties of stone. However, if one were presented with prismatic blades along with a blade core, the pathway from raw material to finished product becomes intuitively clearer. While it may be more difficult to reconstruct the process of changing green hide to useable leather, the pathway is there, as vague and ambiguous as it may seem at first glance. Hence, the question is how do we begin to learn the methods and techniques used by native peoples to process hides and skins. What are the approaches available to us to begin such a study? This thesis will utilize ethnographic accounts, archaeology and the use-wear studies it has generated, historic and modern studies of leather-making technology, and my own experimental studies.

Ethnographic Accounts. One readily available source of information is a perusal of ethnographic accounts. People that actually saw native peoples working hides should have been able to relate to us their hide working methods and techniques. In fact, Schultz (1992) reviewed some 31 ethnographic accounts of 16 historical Plains Indian groups to develop his experimental work with bison hides. Additionally, for the present work I reviewed accounts of other native peoples, such as people of the eastern seaboard (Abbott 1881), Great Lakes people (Ritzenthaler and Ritzenthaler 1969), people of the Northwest Coast (Teit 1900), and modern Ethiopians (Clark and Kurashina 1981; Gallagher 1977). Yet relying solely on ethnographic accounts may not give a true picture of the activities of native peoples despite the fact that the ethnographer observed them engaging in a particular activity. In an article on Eskimo scrapers, Siegel made the above argument, observing that in spite of ethnographic accounts attesting to the fact that these scrapers were used on animal skins, he found use-wear indicating that other contact materials were involved (Siegel 1984, 1986). Although Schultz (1992) argues convincingly that hide-working activities of peoples of the historic era reflect prehistoric hide working activities, the difficulty lies in understanding any indigenous hide processing, whether historic or prehistoric in time.

Without laying blame on ethnographers, the problem with ethnographic accounts is that the writers must generally focus on what they see in a particular place at a given moment in time. Regarding hide processing, this often tends to give us a snapshot of what should be a feature-length film. While ethnographers may have accurately reported what activities they saw, they might have been less than accurate in surmising the reasons for, or the results of, these activities. Furthermore, hide-processing methods may be dependent on environment. The methods used in one environment may not be successful in another. Hide processing methods are also species dependent, particularly regarding size and thickness of the hide. Methods used on bison hides may not be the same as those used on deer hides (cf., for example Mooney 1910 and Ritzenthaler and Ritzenthaler 1969). Because the steps required to process hides are different from region to region, species to species, and product-to-product, ethnographic accounts cannot explain aboriginal hide processing in a comprehensive and holistic fashion. We must look for other approaches as well.

Archaeology and Use-Wear Studies. Other readily available sources of information on native hide processing are archaeological sites where hide-working tools are found. Although bone tools are occasionally found associated with hide processing, as well as various forms of stone tools (see Schultz 1992 for examples), the most prevalent tool found across space and time generally associated with hide processing is the stone endscraper (Hayden 1979, 1986; Shott 1995). This inferred use of endscrapers has largely been substantiated by microscopic use-wear studies and experiments in addition to the general morphology of the tool class (Brink 1978; Hayden 1979; Keeley 1980; Schultz 1992; Siegel 1984; Vaughan 1985). Use-wear studies attempt to discern the function of stone tools by looking at differences in microscopic patterns of wear left on them from the various tasks for which they may have been used. An integral part of these studies is the experimental production of use-wear on replicated stone tools, and the comparison of the resulting experimental use-wear to that found on archaeological specimens. However, interpretations of the results of hide working experiments conducted by various microwear analysts have often not been in agreement and consequently no use-wear features cross-culturally diagnostic of hide working activities have been defined or described (Bamforth 1986; Bamforth et al. 1990; Brink 1978; Hayden 1979, 1986; Keeley 1980; Levi-Sala 1996; Schultz 1992; Siegel 1984; Vaughan 1985). This work will examine in a later section the methods used by various analysts in order to explain their incongruence in describing hide-working use-wear.

Historic and Modern Leather Technology. Any study of indigenous hide processing would be remiss if it did not draw on the available literature dealing with leather production from ancient to modern times. Two comprehensive accounts of these topics are Thorstensen (1985) for modern hide processing techniques and Reed (1972) who covers historic hide processing techniques. The modern studies dealing with the physiology and chemistry of hides allow us to understand the changes that take place in the hide when it is processed, and therefore, what steps are necessary in the processing.

However, these studies deal with modern methods and highly controlled techniques (Thorstensen 1985). The historical methods of hide processing, although rather advanced in terms of both raw materials and products, were largely the results of trial and error and their details often became commonplace, thus making the historical record of hide processing technologies meager (Reed 1972:11). Furthermore, many of the techniques used in Old World recorded history may be not plausible in prehistoric North America. While we certainly need to explore these studies, we cannot rely on them solely for the information we seek.

Experimental Studies. Many researchers have conducted experiments in conjunction with use-wear studies regarding hide processing (Brink 1978; Hayden 1979; Keeley 1980; Levi-Sala 1996; Odell and Odell-Vereecken 1980; Schultz 1989,1992; Semenov 1964; Tringham et al. 1974; Vaughan 1985). The present work will document my own experiments and those of others in processing hides with stone endscrapers. The previous studies of other researchers have all generally tried to define the characteristics of hide working use-wear with varying results and without regard for what the hide produced in the end. In some cases, researchers scraped green hide, in others, tanned leather. This study describes the use-wear characteristics obtained from working green bison hides and, more specifically, asks whether or not different steps in the process of going from green hide to finished product, produce different use-wear characteristics. My experience has taught me that there are certain steps in the process that must occur, that different types of products are available from a green hide and what these are, and to recognize a finished product of high quality as well as how to obtain it. While these experiments may at best, only prove that different steps produce different use-wear characteristics, they can certainly be included with the other lines of evidence to help us better understand primitive hide processing and the use-wear generated on the tools that we believe are associated with this work. The experiments will also provide some idea of how much actual work a hide scraper can do not only in terms of strokes, but also in terms of bison hides (Schiffer 1979:19-23).

Chapter II is a review and analysis of Schultz's (1989,1992) survey of Plains ethnographic accounts, his subsequent experiments, and his resulting model. It incorporates ethnographic accounts from other regions, modern and historic leather making technologies, and my own experiences in working hides and skins to formulate a more holistic and comprehensive model of aboriginal hide processing. Chapters III and IV deal with archeological evidence of hide working in the form of the ubiquitous endscraper, which as Schultz has shown, formed an integral part of the prehistoric hide worker's tool kit. I will review and discuss the literature dealing with use-wear studies and related experiments that have investigated the endscraper's function as a hide-working tool. I will also evaluate these studies and experiments in light of the information presented in Chapter II to determine how they fit the model derived from this information and illustrated in Figure 6. Chapter V outlines the experiment undertaken in this thesis. The scope of the experiment is necessarily narrow enough to be manageable, but the question it seeks to answer is broad enough to apply to any hide working situation utilizing hafted stone endscrapers and "natural" softening agents such as brains, where the hair and grain are removed by mechanical means, that is, scraping.

CHAPTER II

TOWARD A WORKING MODEL OF HIDE PROCESSING

When considering the use native peoples of North America made of hide and skin products, we can only suppose that there was quite a variation in species utilized because of environmental differences, and because hides and skins from different species have different applications. We can further suppose that processing rabbit skins might be considerably different than processing bison hides. Nevertheless, pelts of warm-blooded animals share basic characteristics of anatomy and physiology.

Structure of Hide

Skin is a tough yet flexible membrane that responds to outside stimuli, stores food, expels waste products, regulates body temperature, and affords protection to the animal. Although its structure is complex, Reed (1972:16-19) describes mammalian hide in terms of three layers. These are the epidermis, dermis and hypodermis. The epidermis is the thin, hard outer layer made up of keratin. It is chemically inert and continually flaking, being replaced by new cells formed below that push outward to provide constant protection for the outer skin (Thorstensen 1985:17-18). Cells in the basal layers of the epidermis produce hair, which grows in follicles. About half way down each hair follicle are the associated oil and sweat glands. The follicles extend down into the dermis in such a way that the epidermis and dermis are difficult to separate by mechanical action. In addition, the surface of the dermis is not smooth, but is made up of small protrusions called papillae that interlock with the lower portion of the epidermis at the junction between the two (See Figure 1). The hairs extend down to the lower limit of the papillary layer. The dermal papillary surface is exposed when dehairing takes place by other than mechanical means, for example chemical or biological action. Together with the size and distribution of the now empty hair follicles, the dermal papillary surface reveals the *grain* pattern that is characteristic of tanned leather. The depth of this layer compared to the total thickness of the dermis varies across species and age within species and can be useful in identifying the animal type from which a particular hide product originated. The fibers of the dermal papillary layer are generally denser and more tightly woven than the dermal layer below (Reed 1972:25, 31).

The dermis below the papillary layer forms the major part of the processed hide. It is composed of a complex, three-dimensional network of collagen, elastin, and reticulin fibers as well as connective tissue cells all surrounded by a ground substance. This network of fibers gives hide products their characteristic strength and durability. The ground substance is a sticky fluid containing large ions of mucopolysaccharides and proteins that react strongly with water and chemically bind to collagen. It is responsible for certain functions of the living skin including lubrication, fluid retention, and repair of damaged tissue. Most methods of hide processing cause the removal of at least part of the ground substance because it prevents tanning or softening agents from affecting the collagen fibers (Reed 1972:29-31).

For the purposes of this thesis, we can think of the hypodermis as the flesh layer, which, in all hide-processing operations, is removed. Its tissue is less dense and fibrous than the dermal layer and often contains masses of fat cells and portions of muscle and connective tissue separated from the body wall in the process of skinning (Reed 1972:17).

In the terminology of the leather industry, the skins from large animals are called hides and those from smaller animals are called skins (Reed 1972:13; Thorstensen 1985:20). We adopt this usage here. Although the term “hide working” is generally all-inclusive, “hides” come from such animals as full-grown cattle, horses, or bison, while “skins” refer to sheep, goats, deer, or rabbits. The term “pelt” is used to refer to a green or unfinished hide *or* skin. The term “tanning” is avoided in this discussion of general hide work. The word “processing” is used instead. Tanning is a specific way to process a hide, but it is not the only way, and therefore, the term should not be used when discussing general hide work.

Analysis of Schultz’s Model

Jack Schultz (1989,1992) surveys some 31 ethnographic accounts of 16 Great Plains culture groups. Although he found considerable variety in the descriptions, he also found enough behavioral similarity to define a “Plains way of processing hides” (Schultz 1989:10). He fits these behaviors into a four-stage model: fleshing, scraping, braining, and working. His study was based solely on hide work, his experiments are oriented toward an end product, and his model is practical and realistic regarding the people he studied. The following sections review Schultz’s survey of Plains ethnographies along with his subsequent experiments and also integrate hide-working accounts from other regions, past and present leather-making technology, and qualitative data from my own hide-working experience. This analysis will assess the validity of Schultz's model for a "Plains way of processing hides" and discuss hide working in general in order to construct a model that encompasses different regions and cultures through time.

Preliminary Preparations

Although Schultz defines fleshing as the first step in his model, he discusses three activities that, according to his survey, occur before fleshing. He calls these "preliminary preparations" (Schultz 1989:7, 1992:334). The first involves pegging the hide out on the ground or lacing it into a rectangular frame in order to stretch it. The second consists of draping the hide over an upright beam or post, again he says, for the purpose of stretching it. However, in this case, he states that stretching could only take place at the part of the hide covering the post. He describes the third activity as soaking the hide in a solution of ashes or lye for easier hair removal. This latter activity is addressed in the section on hair removal. In my experience, there is no advantage to be gained from stretching the hide without first removing at least some of the outer membrane, either on the flesh side or the hair side. The purpose of the two activities is not to stretch the hide, but simply to prepare the hide for fleshing, albeit by two different methods, each requiring different tools, a distinction Schultz does not address.

In the first method, the hide is pegged to the ground or laced in a frame, and must be pulled taut because it is suspended with nothing behind it to absorb the force of the fleshing tool, which in this procedure could be the bone or iron fleshers, or the hafted endscrapers, both discussed by Schultz (1989:18-19, 1992:336). Stretching, in and of itself, at this point has little or no effect on the outcome of the hide.

In the second method no actual stretching occurs. The hide is simply draped over a beam, whether vertical, horizontal, or some angle in between and the worker fleshes the hide with a tool analogous in shape and function to a modern drawknife. Schultz (1989:8, 23-24) does not classify these “beamers” as fleshing tools, but describes them as dehairing tools used only on deer. The beams themselves, generally made from a log or half-log, are curved on their dorsal surface, providing a backing with a manageable contact area between the drawknife-like beamer and the hide. A flat surface creates too much contact area, resulting in a mass of tissue in front of the tool that requires too much force to remove efficiently.

Fleshing

Every hide or skin must be fleshed, meaning that all of the muscle, fat, and membrane must be removed from the interior surface, or “flesh side.” This is generally the first step in the process and Schultz defines it as such in his four-stage Plains model (Schultz 1989:12). Fleshing greatly retards bacterial action and subsequent spoilage and permits the hide to dry more quickly. Air drying renders the hide fairly stable, allowing it to be stored or transported without damage, and is one of the earliest known methods of preservation, and certainly the most simple as long as the rate of drying is controlled (Thorstensen 1985:31).

In his survey of Plains accounts, Schultz (1989, 1992) describes three classes of tools used as fleshers. The first group is a chisel-like tool manufactured from the leg-bones either of bison or elk, or from a piece of iron, or from a combination of an iron bit and an organic haft. These tools were used with one hand and often had a thong for the wrist. The distal end was formed at an acute angle to the long axis of the tool and generally had rather deep serrations cut into the acute end so that teeth projected from the edge (Figure 2 and Figure 3). These teeth aided in grabbing the tissue to pull it off. According to information gleaned from his survey, the wrist thong or strap increased the power of the operator [Ewers 1939:50; Mooney 1910:592]. More precisely, the wrist strap keeps the worker's hand from slipping on the tool when delivering the blows required to strip the tissue from the hide. I, like Schultz (1989:46-54), have found this type of scraper to be quick and effective for the initial fleshing of hides that are laced into a frame and are still "green" or damp. The tool does not perform well on dry hide, neither is it efficient at removing all the membrane, which must occur to obtain a quality product.

The second tool type is the classic elbow-shaped scraper, consisting of a typical endscraper bit hafted to an L-shaped handle of antler or wood (Figure 4). Schultz (1989:49-52, 1992:343) found the tool to be very effective at fleshing hides from start to finish, wet or dry. I agree, but having said so, my experiments indicate that removal of the membrane is carried out more efficiently after the hide has dried. Similar to the working edge of the leg-bone flesher, the bit edge of the endscraper is chisel-like in that it is made and sharpened unifacially. The operator grips the tool with one hand near the end of the haft and the other at the elbow near the bit. Some practice is required to deliver the blow so that tissue is removed without cutting the hide. The angle at which the tool is held, the force of the blow, the sharpness of the edge, and the edge angle are all extremely important factors affecting its efficiency in fleshing hides.

The third type, which Schultz (1989:27) calls stone fleshers, are simply modified edge tools, unhafted and made to be used with one or both hands, depending on their size. In order to use any one of these three tool types, the hide must necessarily be pegged to the ground or laced in a frame.

There is yet a fourth type of tool used for fleshing. The beamers discussed above are very effective tools for fleshing any pelt so long as it is damp. The technique employed is somewhat different. With the pelt draped over the beam, the upper end of it is fixed so that it will not slip. The operator places one hand on each end of the tool and with downward pressure against the beam, pushes the tool across the pelt so that tissue is removed. I have successfully fleshed bison hides, cow hides, deerskins, and raccoon skins with a dull drawknife used as a beamer (Figure 2). I have also successfully fleshed deerskins with an unmodified rib bone. In my opinion, it requires less expertise and practice to perfect the use of the beamer as opposed to the toothed leg-bone or the elbow-shaped scraper.

Although Schultz is probably right in his assertion that they were used primarily on deerskins, he is wrong in intimating that beamers were used only for hair removal. Furthermore, one of his own sources relates that the Comanche used “an instrument similar to a drawing knife” for fleshing without distinguishing on what type of hide or skin they used it (Wallace and Hoebel 1986:94). Native peoples used beamers in woodland environments from the Carolinas to British Columbia (Mooney 1910; Ritzenthaler and Ritzenthaler 1969; Teit 1900). Teit (1900:185) reports that the Thompson Indians used a deer ulna or a horse rib. Mooney (1910:593) also mentions a rib bone. Ritzenthaler's account of the Chippewa (1969:85) states that a long bone with a slot cut longitudinally down the center accepted a stone scraper blade. This was replaced in historic times by a cylindrical piece of wood with a common table knife blade embedded in the longitudinal slot. The knife blade was filed flat so as not to cut the hide while pushing it against the hard surface of the beam. Schultz (1989:24) cites accounts of similar compound beamers. The use of the beamer seems more prevalent in woodland environments than on the Plains. This correlates with Schultz's assertion that beamers were used primarily on deerskins although his statement that they were used *only* for *dehairing* deerskins is undoubtedly erroneous. There is a method of hide processing commonly known as "wet scraping" where the beamer is used for both fleshing and dehairing. The wet scraping technique *is* generally associated with deerskins and is discussed in detail in a later section.

Once the fleshing is completed, the pelt is stable enough to be stored or transported as long as its environment remains dry. Two primary deterrents to its stability at this point are the propensity of dry hide to take on moisture from the air, and the fact that the pelage is not removed. If the pelt becomes wet or even moist because of environmental conditions, the hair prevents it from drying quickly. This may cause the hair to slip and eventually the hide will spoil. Nonetheless, processing can occur with the hair on; buffalo robes or furs are examples. Hair-on processing of large hides, such as those of mature bison, requires that thicker areas around the shoulders and rump be thinned so that softening solutions such as brains are able to penetrate throughout the hide's thickness. Thinning of hair-on hides is critical because the solution can only be applied from the flesh side. Buffalo robes are often thinned to the point where the hair follicles are visible from the flesh side. Schultz's review and experimentation (1989, 1992), as well as my own, support the elbow-shaped hafted endscraper as an effective tool for this task. Use of the endscraper in thinning a hide in this fashion is simply a continuation of the fleshing process; however, considerable skill is required to avoid ripping holes when the hide is this thin. Schultz lumps the thinning of hides into his second stage of scraping, along with the removal of hair, but in the case of hair-on hides, thinning from the flesh side is obviously the only alternative.

Hair Removal

Unlike fleshing, not all hides and skins require hair removal to be further processed. Buffalo robes and beaver pelts are two examples of hair-on processing that were widely known by native North Americans. People most likely used hides and skins processed with the hair intact to obtain warmth in cold weather. In many other applications, hair is undesirable and is apt to rub off through use anyway. Therefore, the next major step in the process of hide work is removal of the hair and corresponds to the second step in Schultz's model, which he calls scraping (Schultz 1989:12).

Modern technologies aside, primitive methods of hair removal generally fall into two categories with two basic results. One set of techniques causes the hair to slip and leaves the grain of the pelt intact; the other removes both the hair and the grain. Each imparts a very different character to the pelt, and the method used by native people was based on the desired product. Furthermore, the hair removal method determines subsequent handling of the pelt.

Grain Retained. As mentioned earlier, the third of Schultz's (1989, 1992) preliminary activities gleaned from his survey was soaking the hide in lye or ashes. Soaking the hide in water or merely keeping it damp facilitates hair removal by bacterial action and the addition of a strong base in the form of wood ashes or lye further aids in the loosening of hair and the outer layers of epidermis. Reed (1972) discusses at length the use of lime historically for the depilation of hides. When the hide is treated with a strong base such as lye or lime for a sufficient amount of time, it is possible to simply rub off the hair with the hand or a dull tool. This operation leaves the grain intact, which dictates to a certain degree how the hide is further processed. The remaining grain makes softening difficult when using materials such as brains, the primary softening agent described in ethnographic and other historic accounts (Abbott 1881; Battey 1875; Fletcher and LaFlesche 1911; Forbes 1966; Mason 1895; McClintock 1910; Mooney 1910; Reed 1972; Ritzenthaler and Ritzenthaler 1969; Schultz 1989, 1992; Teit 1900; Waterer 1972; Wallace and Hoebel 1986). Hides dehaired leaving the grain intact more than likely were not processed with fat- and oil-rich materials such as brains, but were either left as rawhide or processed by some other means where the intact grain is not a problem but is instead beneficial. The grain is composed of more densely packed fibers than the dermal layer below it, adding thickness, resilience, and esthetic value to rawhide and grain leather.

Grain Removed. The other method for hair removal is scraping, which results in removal of both hair and the grain layer. There are two techniques by which these results are obtained based on whether the pelt is wet or dry. They require different types of tools and again, impart different characteristics to the finished product, though the differences are not so drastic as those between hides with grain intact and hides with grain removed. One technique commonly called "dry scraping," is the only hair removal technique that proceeds solely by mechanical action and as the term suggests, the scraping takes place when the pelt is dry. The dry scrape technique is what Schultz (1989, 1992) describes and formulates into a "Plains way" of processing hides. In his experimental work, Schultz acknowledges the fact that more than hair must be removed to insure a quality finished product. However, he is mistaken in stating that the removal of the epidermis is what allows penetration of softening agents. The grain layer, which is the dense upper portion of the dermis, must be removed as well (Schultz 1989:58-59; Reed 1972:17-38).

The hide is again either pegged out on the ground or laced into a frame and allowed to dry. In fact, if the hide was fleshed in a frame, the worker only needs to turn the frame around to commence scraping the hair side. Schultz reports that the hafted endscraper already discussed as a fleshing tool, was most often associated with hair removal in the Plains accounts he surveyed (Schultz 1989:19-20). The worker holds the tool in same manner as the fleshing activity and strikes a similar blow. In his experiments, Schultz found the hafted endscraper to be very effective at this task, although he states that he also scraped wet hide efficiently (Schultz 1989:55). In agreement with the ethnographic accounts, my own experience has shown that the hide must be dry in order to remove hair and grain efficiently with the hafted endscraper. The hair and grain are removed in thin strips as shown in Figure 5 due to the relatively narrow contact area provided by the roundness of the edge. A flat edge creates a wide contact area, which would require a tremendous amount of force to remove hair and grain.

The edge angle of the tool, the angle of the tool in relation to the hide, the sharpness of the tool edge, the force of the blow, and the expertise of the worker are all interrelated and exceedingly important factors governing the effectiveness of dry-scraping hides or skins. The bit edge of the endscraper must be smoothly rounded in plan view and free of projections that will score the hide or perhaps rip holes in it. The edge must also be extremely sharp to effectively remove both hair and grain so that a tool used to scrape a bison hide would undergo multiple resharpenings in the haft (Schultz 1989:58-60). Sharpening the edge causes changes in edge angle, which in turn may cause an increase in the force of the blow or change the angle the tool is held in relation to the hide. Multiple retouch episodes will eventually increase the edge angle to the point where the scraper can no longer remove hair and grain no matter what angle the worker holds the tool relative to the hide. When the scraper edge has reached this point, the worker must remove the scraper from the haft and chip a new edge if the tool has enough length, or simply discard it. Gallagher gives a similar description of dry scraping and the reduction of obsidian endscrapers among Ethiopian peoples as late as 1977 (Gallagher 1977:410-412).

As discussed in the fleshing section, hides may be thinned using this same technique. In order to soften hides with materials such as brains, the softening agent must be able to penetrate the dermal fiber layer. Scraping off the entire grain layer and then thinning hides such as those of bison, accomplishes this. The degree to which a hide is thinned depends on the sex, age, and condition of the animal, and the hide worker must recognize by experience when he (or she, more than likely) has reached this point. Deerskins generally do not need thinning, but as stated above, certain areas of bison hides do. Thinning from the hair side insures complete removal of the grain and exposure of the dermal fiber network, allowing adequate penetration of softening agents.

"Wet scraping" is the term commonly applied to the removal of hair and grain from wet skins. I use the term "skins" because the technique is associated with deerskins in the ethnographic accounts that Schultz surveyed and others as well (Ritzenthaler and Ritzenthaler 1969:82; Schultz 1992:334; Teit 1900:185). This technique involves soaking the skin in water, or simply allowing a pelt to sweat, in order to loosen the hair, and is similar to the technique employed in dehairing hides where the grain is to remain intact. In this case, however, the skin remains wet long enough for bacterial and enzymatic action to begin loosening the epidermis and grain layers as well as the hair. Bases such as lye in the form of wood ashes or lime are also helpful additions in the wet scrape technique. Treatment with bases not only eases the removal of hair and grain but also helps to loosen the ground substance and more importantly expands the dermal fiber network, which speeds subsequent tanning or softening operations (Reed 1972:57-59). My own experimental work supports this as well. Also worthy of note is the fact that the addition of acids in the form of fermenting grains has the same effect and historically, is at least as old as the addition of bases (Reed 1972:83). There is ethnographic evidence that southeastern Indians may have used soured corn to achieve similar results (Mooney 1910:593).

The rate at which the grain breaks down is largely dependent on temperature and the hide worker leaves the skin soaking only until she can remove the hair, epidermis, and grain with relatively little difficulty. If allowed to continue beyond this point, and if lye or lime is not used, or the concentration is not of sufficient strength, bacterial action will weaken the dermal fibers, ruining the skin and causing a possible health hazard. Signs of a ruined skin are small pits that appear in the surface along with an atrocious smell and the worker must possess sufficient experience to know when to stop the process.

With the skin thrown over a beam, the hide worker uses some form of a beamer to push off the hair and grain in the same way as indicated in the section on fleshing. As opposed to the edge treatment of the hafted endscraper, the beamer edge is purposefully dull to prevent cutting the skin. The same beaming tools used for fleshing may be used for dehairing and graining so long as they are sufficiently dull (Ritzenthaler and Ritzenthaler 1969; Teit 1900). I have successfully used an unmodified rib bone to remove hair and grain from deerskins.

Wet or dry scraping each has advantages and disadvantages. From my own experimental work, I believe that wet scraping is associated with deerskins to the exclusion of bison hides because larger hides such as those of bison are too heavy and cumbersome to be worked wet. Furthermore, they must be thinned extensively to allow the penetration of softening agents, which cannot be efficiently accomplished by wet scraping. On the other hand, wet scraping deerskin results in softer, thicker buckskin more desirable for clothing than does dry scraping. Dry scraping seems to remove more of the upper layers of the dermis resulting in thinner, harder buckskin with less stretch.

One might assume that wet or dry scraping was influenced by environment, and that dry scraping was a Plains activity because of an arid environment and a lack of available water for soaking, whereas wet scraping was associated with a mesic environment with more abundant fresh water. This is apparently not the case, however. I visited the Museum of the Great Plains in Norman, Oklahoma in order to study leather products made by native peoples. I examined the Tingley collection of buckskin trade items made in the nineteenth century by native peoples, and in most cases, I was able to ascertain that these products were wet scraped, even though Plains tribes manufactured them. Without examining a larger sample of buckskin from other regions as well as the Plains, it is difficult to make assumptions regarding which method was more favored by native people. However, the aforementioned incidence, ethnographic accounts reviewed by Schultz and others cited herein, and my own experience suggests that beaming tools and the wet scrape method were used primarily for deerskins because of their small size, and the wet scrape method produces buckskin of a quality more suitable for clothing.

Bison hides, on the other hand, mandated the use of hafted endscrapers and the dry scrape method because their large size required lacing in a frame or pegging out on the ground, and they generally needed thinning.

Once the hair removal is complete, the resulting pelt is commonly called rawhide, with or without the grain. Rawhide, especially with the grain intact, possesses certain qualities that render it a material of innumerable uses, both utilitarian and artistic. It is more resistant to water than hair-on rawhide; although it too, will eventually soak up water, it dries quicker with no ill effects. Wet rawhide is extremely pliable and easily manipulated, and if allowed to dry while held in a particular shape, it will dry hard and retain that shape until it is wetted enough to soften again. Wet rawhide also undergoes a certain amount of shrinkage when it dries, making rawhide lacing an excellent choice for hafting large objects such as endscrapers (use sinew for smaller items such as arrow points), as well as repairing or reinforcing objects that need to be held tightly. Thick rawhide can be exceedingly hard and durable. Rawhide can be stored for long periods as long as it remains reasonably dry. It is obvious however, that rawhide use is limited and rendering a hide soft requires further processing.

Introducing the Softening Agents

This step corresponds to the “braining” step in Schultz’s (1989:10) four-stage model of Plains hide processing, but just as there is more than “scraping” involved in the dehairing of a hide, there is more to softening a hide than braining. There are several methods by which the pelt may be softened even under primitive conditions. Three methods certainly available to prehistoric peoples of North America are the simple physical manipulation of rawhide, vegetable or bark tanning, and the brain tanning discussed by Schultz (1989, 1992) and the present study.

Skins and thin hides can attain some degree of pliability by physical manipulation including pulling the skin across a twisted rawhide cable or a thin semi-sharp object. I will discuss these methods further in a later section. Nonetheless, the manufacture of leather suitable for comfortable clothing or quality accoutrements, notwithstanding parfleches, drums, or shields usually made of rawhide, generally requires the addition of some softening or tanning agent. Despite the fact that the general process Schultz describes is popularly known as *brain tanning*, softening and tanning are actually two different processes. “Dressed skins” is a term encountered in historical contexts for deerskins that eighteenth century southeastern Indians prepared for the European and domestic markets, more than likely by utilizing brains or a similar softening agent (Krech 1999:158). Softening agents such as brains do not *tan* a hide unless the fats and oils they contain are oxidized by moist heat and converted to aldehydes (Reed 1972:65-72). Furthermore, *tanned* leather is not always soft. The word derives from tannins, which can be traced to an old French word *tann* and the German word *tanne*, both referring to oaks, which possess a high tannin content (Reed 1972:65). Tannins are found in a wide variety of plants, and the use of tannins in hide processing is known as *vegetable tanning* or *bark tanning* since the bark of oaks and other trees are especially high in tannins. Tannins are large complex molecules with astringent properties that create strong chemical bonds with the fiber network, reducing its water content and imparting thermal stability, water resistance, and durability to the hide.

Vegetable tanning is known historically as far back as 4000 years in the Old World (Reed 1972:72-73). It became an important industry there and in North America after European colonization. Ethnographic evidence of the use of vegetable tanning among native peoples in North America is scant at best. I was able to find only one account of native North American vegetable tanning. Mooney cites a report by Henry R. Schoolcraft, which states that the eastern Sioux used oak bark as a tanning agent, but Schoolcraft surmised that the technique was borrowed from European methods (Mooney 1910:592). It seems highly unlikely, however, that native North American peoples had no knowledge of vegetable tanning, especially if one considers the fact that dyes made from vegetable matter would contain tannins, and that in order to utilize acorns for food, these same compounds must be leached out.

In the development of modern chemical tannages, the term *tanned* has come to mean that a pelt has been so treated that it can no longer revert back to raw or green hide, and therefore the utilization of tannins is not the only way to *tan* hides and skins. As long as the hide or skin is stable, where water can no longer affect the fiber network, we may regard it as *tanned*.

As stated above, brains, usually cooked, are the primary softening agent mentioned in the ethnographic accounts that Schultz surveyed. It is not necessary to cook brains to soften hides or skins, but cooking prolongs their use-life. Lightly cooked brains reduce more easily to an oily state than uncooked brains, and the pelt absorbs a warm brain mixture more readily than if the mixture is cold (Edholm and Wilder 1997:131). In addition, several accounts I reviewed point out various materials used along with brains such as liver, grease or fat, bone marrow, soaproot or yucca, and fish head oil (Mason 1895; Mooney 1910; Teit 1900; Wallace and Hoebel 1986). Others cite the use of boiled meat broth, corn, or eggs in place of brains (Fletcher and LaFlesche 1911; Mooney 1910; Ritzenthaler and Ritzenthaler 1969). Brains and other materials high in fat and oil content, once introduced into the fiber network of the pelt, lubricate the fibers, make them somewhat water repellent, and keep them from sticking together so that the result is a soft, flexible leather (Reed 1972:66-67). However, as defined above, it is not tanned leather because repeated wetting can wash the softening agents out of the pelt, causing it to shrink and stiffen.

Brains are applied in different ways according the type of hide or skin. Large hides such as bison and hides or skins with the hair left on require the brains or brain mixture to be applied, usually in a paste-like consistency, with the hand or a brush, and further, hair-on hides or skins require application from the flesh side only. Mooney (1910:592) records the use of soaproot fiber for application. Brains were apparently rubbed in, often with smooth stones also called “slickstones”(Abbott 1881:139-143; Mason 1895:276; Schultz 1989:27-28). Smaller pelts, such as deer, with hair removed were immersed in a mixture of brains and water (Ritzenthaler and Ritzenthaler 1969:82-83). This is an efficient method of getting the proper penetration because a damp pelt readily soaks up water, which carries the fats and oils along with it. The worker then wrings out the water, and fats and oils remain in the pelt. She repeats the soaking and wringing process until she is satisfied that the fats and oils have completely penetrated the dermal fiber network. When lye or lime is used in the removal of hair and grain, it also helps break down the ground substance so that softening agents can penetrate the fiber network more easily, which in turn minimizes the number of braining and wringing cycles. The addition of lye or lime can thus lessen the amount of thinning required for adequate brain penetration. Buffalo robes, on the other hand, require considerable thinning to minimize the weight of the garment, but perhaps just as importantly, thinning allows adequate brain penetration since lye or lime cannot be used because they will loosen the hair.

The application of softening agents such as brains by native North American cultures has counterparts in the modern tanning industry as well as in the historical record of the Old World. *Fatliquoring* is a term that refers to a great number of modern methods for lubricating leather with emulsions of oils in an aqueous system. It affects such physical properties as stretch, break, tensile strength, and comfort (Thorstensen 1985:202-204). *Currying* is an historical method of introducing natural lubricating fats and oils rubbed by hand into heavier leather. Currying was practiced on *tanned* leather to the extent that tanning and currying came to be two distinct trades (Reed 1972:68). As mentioned above, certain treatments with oils can actually tan the pelt. Known in antiquity and still in use today, *oil tanning* is a process in which oil is heated in moist air, oxidizing the oil molecules and converting them to aldehydes, which cross-link with the protein fibers of the pelt, rendering it stable with regard to temperature, alkaline fluids such as perspiration, and water. Oxidized oil molecules also produce complex polymers that coat the dermal fibers, making the fibers themselves hydrophobic, but allowing water to be readily absorbed in the spaces of the network. A well-known example of such leather is the wash-leather commonly called *chamois* (Reed 1972:65-72).

There are differences between these softening methods and the so-called "brain tan" method. The fats and oils used in fatliquoring and currying are applied to tanned leather while in brain tanning, the fats and oils are applied to untanned pelt. In oil tanning, the oils are applied to the untanned pelt with moist heat, which, because of oxidation and cross-linking, actually tans the pelt. In the brain tan process, although the brains may be cooked and applied *warm*, not enough heat is present in the application of the brains to cause oxidation and cross-linking, therefore the pelt is not *tanned*. As stated above, repeated wetting can wash out the fats and oils, causing the pelt to dry stiff. Perhaps the process would be more accurately called "brain softening."

Physical Manipulation of the Pelt

This step corresponds to the fourth and final step in Schultz's model of Plains hide processing. He calls it working, and defines it as "the stretching, pulling, and rubbing that softens the hide" (Schultz 1989:12). In the brain tanning process, all of the above activities are useful in obtaining a soft, dry pelt. Not only may these activities require different tools, but also each activity can be performed with various tools, and conversely, one tool may perform more than one activity. The archaeologist may well experience difficulty assigning a hide-working function to the various tools found at a particular site that *could* be used for "working" a pelt. If we know what actually happens to the pelt during physical manipulation, we may gain a better understanding of which tools might be assigned a hide-working function.

If the pelt were allowed to dry without physical manipulation, it would dry stiff even though adequate penetration of the softening agents was achieved. The fiber network must be open and the fibers separated when the pelt is dry to obtain a soft and flexible result. Therefore, the pelt must be worked *as* it dries. When, how, how much, how often, how hard, are questions that can only be answered through long experience. Working a pelt, or part of a pelt, that is still too wet is a waste of time and energy, on the other hand, if the pelt dries too quickly without proper manipulation, it will not soften unless it is rewetted and worked all over again. Physical manipulation is perhaps the most critical step in the brain tanning method.

Techniques of manipulation are largely dependent on the size and type of pelt, but stretching is of utmost importance for any pelt. Schultz reports that a hide is stretched by lacing it in a frame and describes the "working" in this way:

> While stretched on the frame the hide was stripped and grained. Stripping is squeegeeing off the brain mixture and fluid remaining in the hide with an edged scraping tool (such as the L-shaped scraper, bone flesher, or some other edged tool). Additional rubbing, called graining, follows stripping. Graining tools were the scrapers used in stripping, or simply rough bones or stones. The hide was grained to smooth any rough spots, and give an overall smoothness to the hide. The final activity is sawing the hide, that is, pulling the hide through a rawhide or sinew rope loop to finish the softening and drying of the hide (Schultz 1989:9).

Through many hide-working episodes, it has been my experience that one cannot exert enough tension on a hide, especially large hides such as bison, to stretch it properly by simply lacing it in a frame. Deerskins, for example, are wrung out vigorously, often by twisting with a stick, in order to remove as much of the brain solution as possible (Fletcher and LaFlesche 1911:345; Mooney 1910: 592-593; Ritzenthaler and Ritzenthaler 1969:83-84). The worker may then stretch the skin by draping it over the lap, anchoring it with the toes, and pulling with the hands and knees, while continually turning the skin so that all parts are stretched from all directions. I have found this to be a quick and effective way to stretch deer and other skins, however the worker must exercise caution because this technique often results in unevenly stretched skins that will not lay flat and are therefore difficult to use when sewing clothes, for instance. To obtain a flat, well-stretched skin, the worker may employ a technique known as staking. In this case, the skin is laced in a frame after it has been wrung out and the worker stretches it by pushing against it with a sweeping motion using wooden tool flattened like a paddle on one end or having a stone bit attached (Mooney 1910:592-593; Ritzenthaler and Ritzenthaler 1969: 83-84). Any edged tool could be used as long as it allowed the worker to apply a force strong enough to stretch the skin. This is obviously a good method for large hides such as bison where size and weight would preclude stretching in the lap. The hide or skin must be periodically tightened in the frame as it stretches. This technique evidently corresponds to the stripping activity described by Schultz, but in reality, the edged tools he terms as strippers were not so limited in function as to only remove excess brain solution, but were used as well to bear down against the hide and stretch it.

In the graining tools, Schultz includes the edged scrapers used in stripping along with abrading tools such as rough, porous stones or cancellous bone tissue such as the proximal end of a bison humerus. Abrading tools perform particular functions in finishing. For example, when softening deerskins from which the hair has been removed, a sort of crust forms on both the flesh and grain sides as the wrung-out skin begins to dry, which can keep the skin from finishing as soft as it should. Rubbing in a "sanding" motion with an abrading tool breaks up this crust. Abrading tools are also useful for removing bits of membrane from the flesh side and bits of grain from the grain side that the worker failed to remove in the preceding steps (Edholm and Wilder 1997:140-142). It is also very likely that the "anomalous tools" of wood and bone Schultz describes but assigns no function were used for stretching hides in the frame (Schultz 1989:28-29). Another form of staking makes use of a stationary wooden stake driven into the ground the projecting end of which forms a sharp acute angle albeit with smooth and rounded edges. The worker pulls and stretches the hide or skin back and forth over the top of the stake a portion at a time until the entire pelt is worked. To provide a modern analog as an example, I generally use a dulled ax blade mounted with the bit-edge up to stretch and "break open" drying hides and skins with good success. For staking a hide mounted in a frame, a narrow shovel, commonly known as a sharpshooter, can be used with good effect. Stretching of larger hides and skins could also be accomplished by several workers pulling by hand in all directions at once.

Schultz (1989:9) states that the final activity was pulling the hide through a rawhide or sinew loop. Others report that the hide could also be pulled around a tree trunk or across a limb by two workers, or pulled across a straight length of sinew or rawhide rope fastened on each end (Mooney 1910:592-593; Wallace and Hoebel 1986:95). I generally use steel cable, but have also used twisted rawhide rope with good success, although I have never tried pulling the pelt through a loop. Pulling back and forth across a limb, a stiff rope such as rawhide, or the modern cable for that matter, provides both stretching and abrasion to the hide, especially in the later stages of drying.

It is apparent from the above discussion that the physical manipulation of hides and skins consists of some form of stretching (in all directions) and abrasion and that some activities achieve one or the other and some achieve both. Additionally, any or all of the activities discussed above may be used to manipulate a given pelt. Some are better for early stage softening when the pelt is still rather damp; others work better as the hide becomes drier. Additional activities and tools, not discussed here but similar in nature, may well have been used by hide workers of the past, as long as they provided stretch and abrasion.

Smoking

The preceding sections have followed Schultz's (1989, 1992) four-stage model of bison hide processing. Smoking is not included in his model; he lists it only as an optional step, even though 14 of the 31 accounts he surveyed mention this activity. He gives little detail, simply saying that smoking colors the hide and makes it resistant to water (Schultz 1989:10). After braining, the pelt is white and smoking does indeed color the hide, giving buckskin its characteristic color, for example. Furthermore, it has been my experience that different types of fuel produce different shades of color, for instance oak imparts a golden color while a skin smoked in juniper is more of a grayish shade. The amount of time in the smoke also determines the darkness of a particular shade. The most important characteristic of the wood is that it must produce a good volume of smoke, but no heat. The least amount of heat can wrinkle and stiffen the pelt beyond repair. Rotten wood works well because it generally smolders without bursting into flame, although sawdust, pinecones, and corncobs may also be used successfully (Teit 1900:185-186).

Schultz's statement that smoking makes the hide resistant to water is ambiguous at best. I have also heard people say erroneously that smoking makes a hide or skin waterproof. Water will run through a smoked hide or unsmoked hide with equal ease. The difference is that a smoked hide will dry out soft after wetting, but an unsmoked hide will dry stiff unless it is worked again as it dries. As related above, the brain solution can be washed out of a pelt after repeated wetting, however, once it is smoked, the brain solution can no longer be washed out, and the pelt is now *tanned*. Smoke contains aldehydes formed from the oxidation of woody substances. As discussed above, aldehydes cross-link with the protein fibers of the pelt, rendering it stable with regard to water (Reed 1972:72). Modern tanning operations use aldehyde tanning alone or in conjunction with other tannages to increase shrink temperature and resistance to perspiration, urine, and barnyard acids, and to make the leather more receptive to treatment with waterproofing chemicals (Forbes 1966:5-6; Thorstensen 1985:182-183).

Although smoking imparts tannage to the hide or skin and is certainly beneficial, it was not evidently used in all instances. As noted above, 14 of 31 or about 45% of the accounts Schultz surveyed mention this activity. One reason for this modest percentage of hide-smoking instances may be related to environment. Perhaps repeated wetting was not a great issue for Plains peoples. For example, in his 1910 article on skin dressing, Mooney gives no account of smoking in his description of Plains Indian hide working, but conversely he gives a rather detailed description of hide smoking by Indians of the Carolinas. Further, some peoples may not have specifically incorporated smoking as a step in their method of hide processing because hides and skins were being smoked as finished products in everyday situations as a result of living outdoors. Tipis, for instance, were smoked because of the fire normally built inside and the tops of old tipis were often cut up and used for moccasins since this part was smoked especially well due to the chimney effect in their design (Fletcher and LaFlesche 1911:345; McClintock 1910:8). Even clothing would likely have received enough smoke to be beneficial when worn by people living around a campfire. Yet another instance where smoking would not be needed is if brain-softened pelts were tanned by some other means. Suppose an article of clothing was made from a softened, but unsmoked deerskin and for the sake of decoration, the tailor dyed it with an extract of some vegetable matter containing tannins to obtain a desired color. The article of clothing would then be tanned without smoke.

Smoking, though generally associated with so-called “brain tanning,” is one sure way of obtaining *tanned* leather that was readily available to native peoples, and therefore, I consider it important enough to be included as a step in the process of hide working. The only other readily available method by which tanned, stable leather could be produced was vegetable tanning. As stated above, evidence for this method among pre-Columbian native peoples is sparse; still it is very difficult to accept the idea that the method was unknown. However, it is not the purpose of this thesis to address this problem any further than the discussion in the section on softening, and to suggest vegetable tanning as a strongly possible method of native hide processing.

Summary and Discussion

The preceding sections have followed Schultz's (1989, 1992) four-stage model of bison hide processing. Beginning with his preliminary preparations and through each of his four stages, I have explained what actually happens to the pelt as it progresses, in an attempt to elucidate what it is that "brain tanning" accomplishes and how it relates to hide work in general and to Schultz's model. Each of the preceding sections in this chapter considers a specific stage of the Plains model and shows how it is related to a step in a broader model that goes beyond a particular animal species utilized by a particular culture in a particular place and time. I have also assessed the fitness and expediency of the activities and related tools described by Schultz compared to other accounts of brain tanning, general hide work both ancient and modern, and my own hide working experience.

Although Schultz's model is valuable as starting point toward a more comprehensive model, it has its limits, some of which are summarized here. His model is, by design, limited to a method utilized by Plains culture groups in historic times exploiting one animal species, but Schultz errs in comparing his experimental work with that of other experimenters who were undoubtedly not all using the Plains method (Schultz 1992:342-344). He stresses the importance of ethnographic analogy and criticizes Brink (1978), Keeley (1980), and Semenov (1964) for dehairing hides by letting the hair slip without removing the epidermis, stating that the epidermis must be removed in order for the hide to finish soft. As we have seen, this is dependent on the method of processing used by prehistoric people. Schultz is, of course, describing the brain-tan method in which not only the epidermis, but also the grain layer is removed. Yet, he neglects mentioning the manufacture of buffalo robes, an obviously important Plains commodity, where the hide was softened with brains but the hair, epidermis, and grain layer remained on the hide. Slipping the hair and allowing the grain to remain on the hide is generally associated with vegetable tanning with regard to prehistoric people. In addition, he glosses over the effects of smoking hides and refers not at all to vegetable tanning (Schultz 1989:10, 1992:336). This is perhaps because the ethnographic accounts he reviewed treated these topics similarly, which illustrates the pitfall of relying solely on selected ethnographic accounts when seeking to unravel the behavior of past peoples, especially when comparing activities and tools from different cultural settings. This also illustrates the need for a broader model and a greater understanding of native hide processing when analyzing stone tools, comparing the work of various analysts and experimenters, and formulating our own experiments.

Figure 6 presents a flow chart that illustrates a more holistic model of native hide processing. Each heading corresponds to a preceding section in this chapter, or a topic covered within a section, beginning with fleshing. It also shows where the actual *tanning* step occurs in each method. While relatively general in nature, the model contains all the steps a pelt must go through, from freshly skinned to finished leather, and will allow comparisons to be drawn between cultures and animal species across time and space.

CHAPTER III

THE DEVELOPMENT OF USE-WEAR STUDIES

It is not the purpose of this work to present a critical assessment of use-wear studies in general; instead, the intent is to review and discuss the merits of certain use-wear studies as they relate to hide work, including the experiments that accompany them. However, some general discussion of use-wear research will provide background for the subsequent examination of selected hide-related studies. This chapter presents a review of the evolution of use-wear studies.

A Brief History

People have been curious about the function of stone tools since chipped stone tools were first recognized as such. By the mid-nineteenth century, scholars were exploring the function of stone tools by comparing them to similarly shaped metal tools from their own culture, or with stone tools still being used by contemporary preindustrial peoples. Endscrapers from Paleolithic sites in western Europe and Eskimo skin scrapers was one such analogy (Hayden and Kamminga 1979:2-3). Scholars named stone tools according to this "speculative functional" approach, and so we have terms like knives, borers, engravers, hide scrapers, and saws. Some prehistorians, questioning the validity of this approach, felt that classes should be named according to the tool's morphology and method of manufacture. Hayden and Kamminga (1979:3) again cite the term "scraper," which describes a broad class of retouched tools having little functional consistency. Nonetheless, several scholars at this time began to take note of traces of wear on stone tools. Greenwell and Evans both noted edge rounding and striations while Spurrell and then Curwen conducted some of the first experiments concerning sickle polish. In these experiments and others like them researchers compared experimental and prehistoric wear patterns in order to test an inferred function for a particular set of tools. Other experiments of the late nineteenth and early twentieth century dealt with the efficiency of stone tools at inferred tasks (Hayden and Kamminga 1979:3; Tringham et al. 1974:171-172; Vaughan 1985:3-4). A classic example of this type of study, although it deals with more than tools of stone, is Saxton Pope's experiments with bows and arrows (Pope 1923).

It was not until 1964, however, that the stage was set for the type of use-wear study familiar to archaeologists today. In that year, the English translation of Sergei Semenov's *Prehistoric Technology* was published. This study introduced the wide-scale systematic use of a microscope as a primary tool in discerning the wear traces on stone tools, and utilized systematic experimentation on stone tool use. Semenov focused on the location of polish and striations in order to understand the "kinematics" in various tasks performed by stone tools (Hayden and Kamminga 1979:3; Levi-Sala 1996:1; Semenov 1964; Tringham et al. 1974: 171-172; Vaughan 1985:3-4). Since 1964, microscopic use-wear studies, including the experimental use of stone tools, have become a specialization in the field of archaeology.

The Low-Power Approach

By the mid-1970s, two trends in microwear analysis had developed revolving around two types of use-wear features and based on different microscopic resolutions: the so-called “low-power” and “high-power” approaches. The low-power approach developed from a series of microwear experiments conducted by Ruth Tringham of Harvard and several of her students, including George Odell who subsequently worked to augment the approach (Odell 1979, 1981; Odell and Odell-Vereecken 1980; Tringham et al. 1974). This approach is based on the fracture mechanics of tool stone applied microscopically. The Conference on Lithic Use-Wear in Vancouver in 1977 brought together authorities on fracture mechanics who used these principles to make predictive statements about edge wear characteristics and further defined the approach (Hayden and Kamminga 1979:6-7). Generally, magnification is less than 100x and tool function is determined from the analysis of edge damage primarily in the form of microflake scar characteristics, although edge rounding and polish are also considered (Levi-Sala 1996:2; Odell and Odell-Vereecken 1980:90). Scar characteristics include the number, size, outline, distribution, location, and most importantly, initiation and termination type. Initiations can be cone or point initiations, or the bending type. Terminations having a cone-type initiation may be feather, step, or hinge, while terminations having a bending initiation may be feather, step, hinge, or snap. These categories were defined at the first Conference on Lithic Use-Wear in 1977 and are known as the Ho Ho Classification (Hayden 1979:133-135). Keeley, on the other hand, classified scars according to shape, depth, and size, defining the following types: large, small, and microscopic deep scalar;

large and small shallow scalar; large, small, and microscopic stepped; half-moon breakages (Keeley 1980:24-25).

The low-power approach apparently works well in determining the used portion of an artifact and its use motion as well. According to Odell (1980:98-101), use motion may be longitudinal to the working edge, transverse to the working edge, graving, boring, chopping, projectile, abrading, or pounding. Only the first two categories need concern us here. Longitudinal motions include cutting, sawing, slicing and carving. They generally produce scarring on both surfaces of the working edge, usually alternating from side to side. If striations are present, they are parallel to the edge except in the case of slicing or carving, where they can be transverse or diagonal to the edge. Transverse motions include scraping (which is of the most concern in this thesis), planing, and whittling. In scraping, the scarring is almost always unifacial and if striations are present, they are perpendicular to the edge. Odell states that it is difficult to distinguish between the various activities included within the longitudinal and transverse motion categories, and that little information is gained by the ability to do so (Odell and Odell-Vereecken 1980:98-101). Odell also reports the difficulty of identifying the specific worked material, a characteristic of the low-power method that has been affirmed by other workers as well (Keeley 1980; Levi-Sala 1996; Odell and Odell-Vereecken 1980; Vaughan 1985). However, the worked materials can be separated according to their hardness. Odell defines the following categories: soft, soft medium, hard medium, and hard. *Soft* includes animal and soft vegetable substances, and is characterized by small feather terminated scarring or merely roughened edges. If striations are present, they are faint, but polish frequently occurs. *Soft medium* includes soft or coniferous woods and other "firm but pliable substances." Scarring is large, poorly defined, feather terminated, and not as invasive as in the soft category. *Hard medium* is associated with hard woods, fresh bone, and soaked antler. Scarring is medium sized and hinge terminated with striations and polish frequently present. *Hard* includes bone, antler, and hard dry woods. These cause considerable edge damage with medium-to-large step terminated scars. Polish and striations, although present, are often removed due to the extensive damage, while edge rounding occurs if the artifact is used for a "moderately long" time (Odell and Odell-Vereecken 1980:101).

Workers utilizing the low-power method maintain that the advantages to be realized by use of the approach are economically beneficial in terms of both time and money as opposed to the high-power approach. Microscopes are less expensive and less time is required in performing this level of analysis, thereby allowing a researcher the ability to study a larger sample of tools from a given class or assemblage (Odell and Odell-Vereecken 1980: 88-89). A limitation of the low-power method is that the method cannot identify specific used materials. Further, it has been asserted that microscarring is not diagnostic because it is not always present in spite of the results of the Odells' study cited above (Brink 1978; Keeley 1980; Levi-Sala 1996). Continued use or resharpening of a tool just prior to discard may remove microscarring that was present initially present. Another problem with the utilization of microscarring in determining past use is the difficulty in distinguishing actual use-wear scars from scars produced by retouch or by post-depositional processes, which may produce patterned as well as random scarring. In fact, when describing the microscar characteristics he used, Keeley stated that he only recorded presence or absence of particular scar types because patterning is too difficult to describe, let alone record (Hayden 1979:207, 217; Keeley 1980:1-9,24,173; Vaughan 1985:23-24). The consensus view seems to be that although the low-power approach should be included in any functional analysis because of the information it can provide, it cannot be used with sufficient confidence as the sole use-wear method in an analysis.

The High-Power Approach

In the introductory chapter of the book documenting the first Conference on Lithic Use-Wear held in 1977, Hayden and Kamminga wrote that the most significant development in the study of polish was Lawrence Keeley's claim that specific contact materials produced specific polishes when viewed at high levels of magnification (Hayden and Kamminga 1979:8). Although Semenov had used high magnifications, Keeley's work became the standard for the "high-power approach" in the 1980s. The method commonly utilizes magnifications of 100x to 400x with most identification and photography done at 200x, and as noted above, polishes are the most diagnostic features (Newcomer and Keeley 1979:199).

Keeley gained credibility and support for this method by his performance in "blind tests," where his task was to identify the used area, the use motion, and the contact material. Subsequently, Odell performed a like test using the low-power approach, and the results of the two tests were ultimately compared (Keeley 1980; Odell and Odell-Vereecken 1980). (The results of Odell's test were referred to in the previous section to aid in describing the low-power method.) Keeley used sixteen experimental pieces of which he identified 14 correctly (87.5%) regarding used area, 12 correctly (75%) regarding activity or use motion, and 10 correctly (62.5%) regarding contact material. Odell, using low power, scored 79%, 69.4%, and 38.7% respectively in the three categories. By using the four-part relative hardness scale described above in place of specific contact materials, Odell was able boost his score in the latter category to 61.3% (Odell and Odell-Vereecken 1980:116). Thus, it seemed that the two approaches are comparable with regard to identifying the used area of a tool and its use motion. However, the high-power method seemed the more valuable by providing a researcher, who was well versed in the appearance of various polishes, with specific contact material. As Odell pointed out, the high-power approach is more expensive in terms of time and money. The method requires incident light microscopes that are more expensive, and more time is required to analyze each piece. Workers must sometimes treat the surface of the piece to increase the reflection of surface light, and the working distance is less with these microscopes, making it difficult to work with certain pieces (Odell and Odell-Vereecken 1980:88-89; Keeley 1980:12-13).

Subsequent studies supported Keeley's results, indicating that there is indeed a direct causal relationship between the particular appearance of a polish and a specific worked material and coining terms like "bone polish" or "hide polish." Material specific terms such as these became widely accepted and widely disseminated. Many microphotographs have been published, implying that one can memorize the appearance of polish from any number of contact materials (Levi-Sala 1996; Vaughan 1985).

More Recent Studies

The high-power approach has problems apart from those of expense, however. The primary question remains, despite the claims of Keeley and other researchers, whether the appearance of a polish can be directly correlated to a specific contact material with any certainty. A related problem with polish is how to describe its appearance. Descriptions have been for the most part, very subjective, with terms like “bright,” “matte,” “dull,” “greasy,” or “pitted.” This terminology and the overlapping characteristics of polish appearance have made it problematical for analysts to repeat the experiments of others or to study use-wear without creating their own experimental program and learning the appearance of polishes firsthand. Not that doing one’s own experimentation is a bad idea, but the analyst must be willing to spend a great deal of time and have access to the necessary equipment to accomplish this work. Although attempts have been made, the appearance of polish is difficult to quantify, and this difficulty, apart from the subjective terminology, is related to the nature of polish and how it forms (Grace 1989). Analysts have wrestled with this problem at least as far back as the first Conference on Lithic Use-Wear, where three papers were presented on the nature and formation of polish (Diamond 1979; Del Bene 1979; Kamminga 1979). According to Levi-Sala (1996:3), four key theories have evolved from these and other polish formation studies:

1. Polish is additive as in the case of sickle sheen, where plant silica is deposited on the surface [Witthoft 1967].
2. Polish is a subtractive process, where attrition causes removal of microscopic parts of the surface with or without a related chemical process [Diamond 1979; Masson et al. 1981].
3. Polish is caused by the layered build-up of an amorphous silica gel, which traps phytoliths and other plant cell elements and is the result of heat due to friction [Anderson-Gerfaud 1981].
4. Polish is the result of some combination of the above processes [Del Bene 1979; Kamminga 1979; Meeks et al. 1982; Unger-Hamilton 1984].

Proponents of the silica gel layer theory, including Vaughan (1985), report that plant families could be identified when phytoliths and other plant residues trapped in the silica gel layer were viewed with scanning electron microscopy (SEM). Others, including Levi-Sala (1996), disagree, arguing that there is no evidence for the high temperatures evidently necessary to create a silica gel layer especially when polish covers the entire working edge of a tool, and furthermore, such a layer would be too thin to trap phytoliths or other organic particles. While it seems plausible that working plants may produce a substantial amount of heat, the production of heat would seem minimal when cutting meat, staking a pelt, or fleshing a green hide or skin. Levi-Sala argues instead that “polish is a smoothing of the flint surface produced by the removal of surficial asperities which are sometimes dragged across the surface flattening it. The smoother and flatter surface reflects light more uniformly and appears as a ‘polished’ surface under the optical microscope" (Levi-Sala 1996:4). She further suggests that the "surficial asperities," after being broken away, contribute to the polish. In a hide-working experiment, she found flint crystals imbedded in the hide, causing polish to develop rather quickly. She also found that the presence of a liquid medium aided polish development and theorizes that it causes the retention of the rock particles near the contact point between the tool and the worked material. The particles and liquid "form a slurry which promotes wear by plastic deformation even while reducing friction" (Levi-Sala 1996:67-68). In addition, Anderson reports greater polish development when animal or plant material is worked in a damp state (Anderson 1980).

On the other hand, Kay (1998) argues that there are in essence two types of polish observed at around 200x-400x: frictional (abrasive) and depositional (additive). He further divides frictional polish into "abrasive" and "smooth abrasive" and provides characteristics of each. The intermediately developed abrasive polish invariably contains striae, which are located on the tool's leading edge and/or on high flake arrises interior to the edge. The lengths of these striae reflect the invasiveness of the wear, which is determined by the hardness of the contact material. The more extensively developed smooth abrasive polish is the result of long-term contact between the tool and a pliable material that is very often associated with abrading materials much like hide in the presence of sand or grit. Characteristics of smooth abrasive polish are a broad contact zone whose surface texture is smooth and highly reflective, worn striae generally lacking both depth and shape, and abrasive planing of the microtopography along with the extensive rounding of edges and arrises (Kay 1998:752-756).

The depositional or “additive” polish type occurs where soluble inorganic material bonds to the stone surface areas of high relief. Although Kay declines to speculate on the nature or composition of this material i.e., whether amorphous silica gel is involved, he postulates the remodeling of the tool surface by the deposition of thin polish layers that “fill in” abraded or striated polish areas. He further proposes that the bonded material may then become striated and worn through further use as well (Kay 1998:756-758). This suggests that polish formation is progressive and sequential, and that polish characteristics are determined by the duration of tool use. Kay also describes the crystallization of the soluble inorganic material that may sometimes occur on the trailing side of the polish border. This phenomenon appears as bright white filaments extruded from, and anchored to, the edge of the polish and suspended above the tool surface (See Plate 4C and Plate 5I).

Several variables apparently influence the formation of polish: the hardness of both the flint and the worked material, the presence or absence of abrasives, the presence or absence of a fluid medium, the motion and angle of the tool relative to the work, the force with which the worker applies the tool, and the duration of the work. In fact, the characteristics that these variables may impart to the appearance of polish on a particular tool edge can overlap to the degree that they are indistinguishable. In other words, there is no direct correlation between polish alone and the worked material. Post-depositional friction from sediment along with chemical action can also affect the appearance of use-polish, sometimes replacing it with post-depositional polish, or the two may overlap, making them indistinguishable as well (Grace 1989; Levi-Sala 1996:4-8).

Analysts in several recent studies have moved toward a broader multi-variant method of functional analysis where all variables thought to be functionally diagnostic are taken into account, including raw material, morphology, macroscopic and microscopic edge damage, polish, and linear indicators. These studies utilize examinations of morphology and macrowear, context, low- and high-power microscopy as well as experiments to test their interpretations. Analysts make interpretations based on a variety of attributes rather than either polish or edge damage alone (Grace 1989; Hudler 1997; Levi-Sala 1996). The method has also recently been used on bone tools (LeMoine 1997). Keeley's relatively high success rate in the blind test may have been achieved because he implicitly used similar information, such as morphology, edge angle, and edge wear, in addition to polish to identify contact material, although the implication was that polish was the only criteria. Grace (1989) divides this multi-dimensional approach into three levels of analysis. The first he calls edge analysis, and is based on morphological attributes of the used edge and macrowear. The second level includes, in addition to first level attributes, microwear edge damage and rounding utilizing low-power microscopy. The third level comprises high-power microscopy for studying polish and linear indicators in addition to the first two levels.

Along with using the multi-variant approach, recent analysts have changed methods of cleaning tools prior to analysis from the technique Keeley established to one that is somewhat less aggressive. Studies show that cleaning with biological detergents along with ultra-sonic cleaning successfully removes organic residues, and that subsequent chemical cleaning does not improve the condition of the polished surface.

Further, experiments show that use of even the least caustic chemicals may alter the surface of unused flint (Grace 1989; Levi-Sala 1996). In his functional analysis of artifacts from the Wilson-Leonard site, Kay states, “No Wilson-Leonard artifact was subjected to chemical cleaning beyond an occasional wipe with a clean cotton ball soaked in methyl alcohol to remove oils from tool surfaces” (Kay 1998:746). Hudler concludes from his cleaning experiments that residues overlay or mix with polishes, changing their appearance, and that acid cleaning not only removes residues, but also linear motion indicators existing in the residue. Therefore, archaeological tools should be examined carefully and photographed microscopically before cleaning with chemicals (Hudler 1997:5-7; Shafer and Holloway 1979).

Summary

The study of use-wear has come to incorporate many lines of evidence in its attempt to answer questions about the past use of stone tools. Information derived from morphology, macroscopic examination, context and association, low- and high-power microscopy, together with pertinent evidence from other sources such as environmental studies, may all be used to infer the uses of a tool. These lines of evidence can be used to corroborate particular use-wear characteristics and aid in drawing an inference. Use-wear analysis has come to be regarded as only a part of, albeit a potentially helpful supplement to, lithic analysis. Much work remains to be done regarding the formation of polish as well as the effects of post-depositional processes. In the case of hide processing, researchers should attempt to standardize their experiments to foster replicability and communication. Animal hides and skins are complex organs capable of transformation into many potential products by many pathways, and knowledge of hide work can only produce better research.

CHAPTER IV

USE-WEAR EXPERIMENTS RELATED TO HIDE PROCESSING

In 1979, Brian Hayden, upon completing his analysis of a collection of Eskimo scrapers, wrote that since a scraper from the Plains exhibited the same characteristics as the Eskimo scrapers, he hoped that "these characteristics may be diagnostic of skin-working tools over large areas of the world" (Hayden 1979:227). It seems that this has not been born out by subsequent studies. This chapter explores some of the reasons why hide processing presents difficulties for researchers conducting use-wear studies. It begins with a discussion of experimental validity and reliability followed by a review of some examples of the experimental portions of past use-wear studies dealing with hides and skins in order to determine and examine the reasons why use-wear features diagnostic of hide-working in all places and times have not been agreed on by various researchers (Schultz 1992).

The Validity of Experimental Archaeology

As is apparent from the discussion above, the purpose of studying the use-wear of stone tools is to determine, as closely as possible, what contact material and what manner of use produced the characteristics observed on the tools during analysis. By and large, use-wear studies such as those cited in Chapter III incorporate experimentation into their analyses as a means of comparing the characteristics resulting from stone tool use of the past to the characteristics resulting from present-day experimental use of analogous stone tools. For such a comparison to be valid, the experimental tool use should approximate past use. Arguing the “low-power”-“high power” techniques in an exchange with Siegel (1984), Bamforth (1986:61) stated that microwear analysis is valid if it “actually measures what it is supposed to measure when it is applied under the conditions in which it will be applied in practice.” Although he was discussing microscopic techniques, the argument is relevant to the related experiments. How a tool was used in the past is what we would like to know and is the reason for the use-wear analysis in the first place (Brink 1978 14-16). How adequately does the experimental tool use in a modern study reflect the use of that tool in the past? How can we best approximate the past use of a tool experimentally today so that a valid comparison between past and experimental use-wear characteristics can be made? This is a broad question that is best answered on a situational basis, where the conditions requisite to a particular tool class or worked material may be addressed and met. If we want to consider woodworking, for example, the experimental tool should of course be used on wood. However, this is only the beginning. We need to know at least some of the properties of wood. There are many ways to work wood, including chopping, scraping or planing, carving, and burnishing; therefore, it would also be helpful if we knew what could be manufactured from the wood by the tool in question. The size and morphology of the tool often dictates how the wood was worked. In addition, some knowledge of past wood working technology as well as the past environment is crucial (Coles 1973:15-16).

In the present work, ethnographic accounts, together with years of practice, and a general study of hide-work are used to investigate the use and use-wear of endscrapers. First of all, the ethnographic accounts cited in Chapter II of this thesis and by Schultz (1989) reveal that the hafted endscraper is the primary bison hide-working tool used by indigenous North Americans and that certain hide-working methods and techniques accompany the use of this tool. Further, Schultz (1989, 1992) argues convincingly that prehistoric North Americans probably used the tool and the techniques as well. Secondly, the study of hide-work in general provides an understanding of the changes the green pelt must undergo to produce a certain product and also reveals some idea of what products are possible using this tool. Relating this knowledge back to the indigenous methods and techniques found in the ethnographic accounts in turn provides an understanding of working hides under the constraints imposed by the technology as well as those imposed by the hides themselves. Finally, years of practice render the researcher adept with both tool and technique thereby removing at least some of the clumsiness and inefficiency that is bound to accompany a researcher with little or no practical experience (Coles 1973:15-16; Frison 1978:301-328). Hide-working practice is especially beneficial if it is kept task-oriented with an eye toward a specific end product of good quality. The focus of this thesis is on hide work, as opposed to more broad based studies where many contact materials are examined. While the reliability of any archaeological experiment can never be assumed, a more narrow focus along with both the general and ethnographic study of hide processing, and practical experience working hides and skins should aid in the approximation of past tool use and serve as a basis for the following discussion.

Conflicting Results of Hide-Working Use-Wear Studies

This section cites several hide-related use-wear studies whose results seem to be conflicting, contradictory, and at the very least, confusing. This confusion is in part due to the handling of the hide or skin by the experimenter. For example, in the 1979 study of Eskimo scrapers mentioned previously, Hayden fleshed and scraped a fresh deerskin with an Eskimo scraper he had replicated (Hayden 1979:224-225). The reader must assume that he removed *all* the flesh, fat, and membrane because Hayden gives no description of the process, other than to recount that he spent hours fleshing the skin. If he did not remove all the tissue, then his experiment does not approximate fleshing tool use as discussed in Chapter II and subsequent steps in the process become much more difficult to achieve. Furthermore, a practiced hide worker would never spend “hours” fleshing one deerskin. He then relates that he “cured” the skin in brine, but again does not describe this process or why it was necessary; neither does he indicate whether he washed the salt from the skin before he began scraping it. Hayden does note that abrasion on the tool became markedly more pronounced as it began to dry. If the salt contributed to the abrasion, I do not know, but he should have reported whether or not it was present on the skin.

Hayden also neglects to describe his treatment of the skin regarding hair. The reader does not know whether he left the hair on or removed it. Removing the hair by scraping may also have contributed to the increase in abrasion that he observed. Hayden states that he scraped the skin, not only to flesh it, but also in order to soften it. The reader must suppose that in scraping the skin to flesh it, at least some, if not all tissue was removed and any additional scraping would thin the skin. Deerskins do not generally require thinning and too much scraping can easily produce a hole. To substantiate his experimental work, Hayden cites two ethnographic accounts (1979:225), the first of which describes fleshing followed by "breaking the grain" or in other words, physically manipulating a dried skin in order to soften it [Murdoch 1892:296-297]. I referred to a similar method of physical manipulation called "staking" in Chapter II. Now the ethnographer describes the tool as blunt, therefore it could only be used for softening and not for thinning, or for that matter, hair removal. The second account [cited by Wedel 1970, from Mason 1891:585,586] stresses the fact that the scrapers were constantly sharpened to maintain a keen edge, which indicates thinning, fleshing, or hair removal, but not softening. In other words, the two accounts describe two distinct steps in the model of hide processing formulated in Chapter II: scraping for the purpose of tissue removal and scraping for the purpose of "breaking" or softening. Hayden does not address these differences, nor does he comment on the keenness of his experimental scraper or the condition of the deerskin upon completion of his experiment. All of which would have made his work not only less confusing, but also a better approximation of the activities of the Eskimo hide workers.

Lawrence Keeley's experimental program described in the third chapter of his 1980 book provides other examples of confusion for the reader due to a lack of understanding of hide processing (Keeley 1980:15-83). In the beginning of the chapter, Keeley outlines his general principles and aims. The third of these aims emphasizes the *actualistic* nature of his work in replicating aboriginal conditions to "insure comparability with Paleolithic implements" listing as an example "scraping the flesh off a fresh hide" (Keeley 1980:15). However, Keeley's method of fleshing is very different from ethnographic accounts I have seen and Schultz notes this as well (Schultz 1992:343). Keeley uses a "combination of slicing and shaving motions (as opposed to the 'grating' motion of hide scraping)" but cites no ethnographic accounts or any other source to substantiate such a method (Keeley 1980:51-52). I have attempted to flesh both deerskins and bison hides using this motion with both unretouched and retouched flake tools similar to those used by Keeley (Keeley 1980: Figures 127-129). I found it practically impossible to remove all the tissue that subsequent hide work demands, and any tissue removal except for large pieces was extremely difficult. Instead, I have found the "hide scraping motion" using the hafted endscraper to be most effective.

Another example concerns Keeley's hide work regarding dehairing. He undertook only one experiment on hair removal, concluding that it was so quickly and efficiently accomplished that no microwear was discernable. He conducted this experiment on a hare skin left in a "damp condition for a week to loosen the hair" (Keeley 1980:53). Granting that the structure of this experiment may have been relevant to "certain British Lower Paleolithic industries" (Keeley 1980:5), in some parts of the world not only would the hair slip and fall out on its own, a damp hare skin would be rotten in a week's time. Like Hayden, Keeley makes no comment concerning the condition of the skin upon completion of the experiment; neither does he discuss the difference between allowing the hair to slip and scraping the skin to remove it. As discussed in Chapter II of this thesis, slipping the hair from the pelt leaves the grain intact and involves bacterial and enzymatic action that loosens the hair allowing it to be easily rubbed off the damp pelt. From Keeley's description this is evidently the method he employed rather than either the dry-scrape or the wet-scrape method, either of which could impart very different use-wear characteristics than he obtained. Leaving the grain intact makes softening the pelt with fat- and oil-rich materials such as brains difficult and is usually associated with vegetable tanning. By not exploring other methods of depilation and/or treatment of the grain, Keeley not only may have missed the use-wear characteristics that may be associated with them, but he also imposed a certain system of hide work on the people he studied without substantiation or acknowledgement to the reader.

For similar reasons, results from the hide-related portions of John W. Brink's microwear study are skewed (Brink 1978). Unlike Keeley, Brink stated at the outset that his work was not task-oriented because if it had been so, he felt that he would have sacrificed control and thus, repeatability of his experiments (Brink 1978:20-21,40-42). However, in retaining control over variables, he instead sacrificed approximating past tool use regarding the scraping of hides and skins. For instance, he hafted his experimental scrapers with dental floss when rawhide strips would have been more appropriate. Damp rawhide lacing shrinks as it dries and resists cutting by the tool edges, a problem that Brink acknowledges with the dental floss. Unlike dental floss, dried rawhide holds the scraper tightly with little or no movement, a difference that could affect use-wear characteristics (especially haft-wear). Rawhide is not difficult to obtain and this is one instance where the use of ethnographic analogy in no wise would have raised the margin of error or impaired the replicability of the experiment (Brink 1978:21).

Brink also attempted to distinguish between the use-wear characteristics resulting from different steps in the hide working process, namely fleshing and dehairing, and was not able to do so. One purpose of my thesis (listed in Chapter I) is to also test this hypothesis, which states that different steps in the process will produce different use-wear characteristics. Therefore, I will discuss Brink's methods and observations in order to explain why he perceived no differences between fleshing and dehairing with a hafted endscraper.

In his first experiment, Brink fleshed cowhides in a "fresh condition". He cut and fleshed one-meter square and smaller pieces of hide, and as a scraper became dull, he repeatedly froze the hide in order to keep the hide fresh while he photographed the scraper edges (Brink 1978:94-95). However, pelts can be successfully fleshed after they dry, as in the case of large hides, parts of which will generally become dry before fleshing is complete depending on humidity, temperature, and air movement. He reports his results as follows. "Hafted scraping tools proved to be quite ineffective at fleshing a fresh hide. The distal end of the scrapers simply slid over the hide failing to grip the pieces of meat and fat on the hide surface. The greasy nature of the fresh hide added to this inefficiency of the stone tools." Brink goes on to speculate that edge angle may influence the scraper's effectiveness in fleshing. He also attempted to hold constant the angle of the tool to the hide (Brink 1978:95). Conversely, Schultz found the hafted endscraper to be an effective fleshing tool and states that not only is edge angle an important factor, but also that keenness of the edge is equally important (Schultz 1992:343). Although my own experimental results agree for the most part with those of Schultz, I would add yet a third criteria for effective fleshing that is at the very least as important as sharpness and edge angle, and that is technique. Technique acquired by much practice allows the hide worker to successfully flesh a pelt even when edge angle and edge sharpness are not optimum. I have fleshed cowhides and bison hides freshly skinned, frozen then thawed, and dried to rawhide, all with the hafted endscraper as described by Brink and Schultz. I have also fleshed more than one large green cowhide without the necessity of resharpening the scraper. In order to flesh a hide, the scraper is not held at some constant angle, but instead the angle at which the scraper is held must change as different parts of the pelt are fleshed, and further, the angle is dependent on edge angle and the angle at which the work is resting. Also of utmost importance is the amount and type of force the worker applies to the scraper as it contacts the hide, two variables that are difficult to describe or quantify. Brink attested to this as well and attempted to hold a consistent pressure in each of his experiments (Brink 1978:41-42). Consistency aside, the important point is that the worker must apply sufficient force to tear through the tissue and then sustain the force throughout the stroke so that the tissue is dislodged at the location of contact between the tool and the hide (See Figure 7).

On the other hand, Brink was successful in fleshing sun-dried cowhides, although his terminology is confusing. He no longer calls the procedure “fleshing,” but discusses it under a separate heading that he calls “Dry Scraping Clean Cow Hide” (Brink 1978:96). He describes the procedure as follows:

> In contrast to the fleshing experiments, the hafted scrapers used on a sun-dried hide effectively removed the dried bits of fat and meat as well as the membrane-like layer known as adipose tissue. The hide became extremely stiff when dried and provided a firm working surface for the scrapers. The fats and tissue, having lost their greasy texture, were scraped away in thin strips that curled away from the tool edge. There was little build up of material on the working edge and clearing the edge was not required (Brink 1978:96-97).

Although Brink contrasts this procedure with the work he did on fresh hide, it is still fleshing. Waiting until a hide is dry before fleshing may be advantageous in some environments, but in others may cause problems due to bacterial activity especially where humidity is high. As noted above, parts of a large hide may become dry before fleshing is complete, again depending on humidity, temperature, and air movement. When fleshing a large hide, the hide is in a continual state of drying, neither completely damp nor completely dry, unless it is purposefully dried to begin with. For this reason, cutting the hide into small pieces in order to keep it “fresh” does not approximate hide work according to ethnographic accounts nor is it likely to approximate prehistoric activity. Use-wear characteristics attributed to fleshing could therefore be a result of work on damp hide, dry hide, or anything in between. Brink noted a rapid dulling along with rounding and polishing when fleshing dry hide and little or no use-wear when fleshing damp hide (Brink 1978:100-102). He evidently did no work with hides between these two absolutes.

Brink states that the hafted endscraper was also very efficient at removing hair. He used only one experimental tool for this purpose because he found it so effective. Use-wear was slow to develop, involving only slight alterations to the tool edge and a sharp edge was not essential (Brink 1978:98-99). However, Brink used the same method as Keeley used on his damp hare skin. Prior to scraping, Brink allowed the hide to soak for 48 hours, loosening the hair. As Brink says, "One, the dehairing task does not seem to require a very sharp tool edge. Once the follicles were loosened the hair could be removed by dragging almost anything over the hide" (Brink 1978:99). It is obvious that Brink, like Keeley is removing the hair but keeping the grain intact, a very different method than removing the hair and grain together as discussed in Chapter II and presented in our model. Based on his experiments Brink was unable to distinguish between use-wear characteristics resulting from fleshing and dehairing, in other words, they were very similar. However, because he found endscrapers ineffective at fleshing but effective at dehairing, he argues that any such wear patterns found on prehistoric tools must indicate dehairing (Brink 1978:112).

Brink is in error here on several counts. One is that the hafted endscraper is not an effective fleshing tool. It is indeed effective regardless of the stage of drying provided the edge angle is less than ninety degrees, the edge is not dull, and the worker has the proper skill. Another is his failure to recognize that fleshing dried hide *is* still fleshing. Fleshing is most likely to occur *as* the hide dries, especially where large hides are concerned. In other words, in fleshing a hide from start to finish, the last traces left on the tool will be a result of scraping hide that is dry or somewhere between damp and dry. Still another error lies in the assumption that hair removal is only accomplished by slipping, thus leaving the grain intact. If Brink had conducted his dehairing experiments according to ethnographic accounts of bison hide processing on the Plains, he may have found distinguishable differences between fleshing and dehairing use-wear characteristics. Consulting the ethnographic accounts may also have enhanced the approximation of past tool use and the repeatability for other researchers yet diminished the confusion Brink's experiments have generated.

There are similar problems with the hide-related portions of Patrick Vaughan's 1985 use-wear study. Vaughan makes the mistake of equating the properties of dry hide and tanned leather, and in addition, fails to differentiate between distinct activities. "As a substitute for drying fresh hides outdoors to produce dry hides, commercially tanned hides of deer, rabbit, and cow (both thick leather and supple suede) were worked in a dry state, slightly redampened, and with lard spread over the working area" (Vaughan 1985:15). While he acknowledges that in the past dry hides were often scraped, he also states "it was also common for hides to be softened by scraping with stone tools only after they had been tanned in some natural solution such as deer brains" (Vaughan 1985:15). Instead of actually scraping dry hide in order to thin it, or using the scraper to physically manipulate dry hide in order to soften it as in staking, he uses the tool on tanned leather. Working tanned leather with the addition of lard is a form of *currying*, a process designed to further soften and thin heavy leathers (Reed 1972:67-68). The currying process will further soften commercially tanned leather, as well as hides treated with "natural" softening solutions, although only heavy or thick leathers would require this treatment. Nevertheless, *untanned* hides and skins must still go through some initial softening stage if they are to become finished leather. If Vaughan is attempting to replicate the softening of hides by physical manipulation using the tool to stake the hide but is actually replicating some form of the currying process, then his analogy is faulty. For instance in the "brain-tan" process, the worker can recognize the point at which rawhide changes to leather during physical manipulation, but how does one know when *tanned* leather has been worked enough? Chapter II of this thesis contains some discussion of the properties of dry hide, in other words rawhide, and tanned leather. Suffice it to say here that their properties are greatly different with rawhide being much harder and more inflexible, while commercially tanned leather of any type is much softer and more flexible. One has only to make a visual and tactile inspection to note the differences and to hypothesize that the respective use-wear characteristics and attrition rates associated with them are likely to be different as well.

There are other problems. First, Vaughan is mistaken in his comment that solutions such as deer brains turn pelt into tanned leather. As discussed in Chapter II, brains and other such "natural solutions" are for softening hides and can be washed out, allowing the pelt to revert to rawhide. Tannage of hides and skins treated with such softening agents is achieved by smoking. Smoke-tanned leather is stable, and water no longer can affect the dermal fiber network. There are "natural solutions" that will impart *tannage*, and these of course are aqueous solutions of plant material containing tannins, in other words, vegetable tanning. However, vegetable or bark tanning is a totally different process requiring a much longer time period producing a product with very different properties from the "brain-tanning" generally associated with native North American peoples (Reed 1972:72-76). Conceding the possibility that the people who used the tools Vaughan studied may have known and used vegetable tanning to process their hides and skins, he makes no distinction between the methods required by vegetable tanning and the so-called "brain tanning" described in this thesis. Secondly, like Hayden, Vaughan loosely uses the term "scraping" in conjunction with softening hides. Scrapers used to soften hides or skins have no need of a keen edge because removal of material is not desirable at this point, instead they are used to break down, stretch, and separate the fibers of the dermal network. On the other hand, scrapers that actually remove material from the hide as in fleshing, dehairing, and thinning, need a sharper edge to function. This distinction regarding the tool edge could well influence the identification of use-wear characteristics.

Yet another problem with Vaughan's study concerns his approximation of past tool use. Vaughan states that he attempted to conduct his experiments in a realistic manner. "On the other hand, meaningful use-wear traces intended for the functional analysis of prehistoric stone tools could only result from authentically re-created aboriginal conditions." He goes on to say that although he did not attempt to process a hide completely, he conducted limited versions of such tasks with the same materials and motions as would have been used in the past (Vaughan 1985:15). Regarding material, it is very doubtful that prehistoric hide workers scraped commercial leather tanned with chemicals in place of rawhide. As for motion, Vaughan's description casts some doubt on the authenticity of his re-created aboriginal conditions. Like Keeley, Vaughan states that fleshing "is most efficiently accomplished by a slicing or shaving motion (i.e., longitudinal action) rather than a scraping action. Dehairing the outside of an animal skin also necessitates the same motion, unless the hairs are just pushed off easily with a bone or antler once the skin has been treated" (Vaughan 1985:38). Again, I have found this motion to be quite inefficient in removing *all* the flesh, fat, and membrane, a requirement for adequate penetration of brains or other softening agents. Even in the event that the hide will not be further processed but simply used as rawhide, removal of all the tissue ensures a durable, less odiferous, and esthetically pleasing product. Vaughan also assumes, as did Keeley and Brink, that dehairing is accomplished by slipping, leaving the grain intact, which essentially precludes using brains or other natural *softening* agents but indicates instead either the production of rawhide or *tanned* leather utilizing tannic acid derived from plant material. These researchers do not present the various methods of hide processing, and thus do not distinguish between them.

Schultz (1989, 1992) recognized the arbitrary nature of these studies and for this reason based his experimental work on ethnographic accounts of the people that he studied, attempting to approximate past behavior as closely as possible. One of the questions he sought to answer was whether the hafted endscraper is an efficient tool for processing bison hides using an ethnographically documented "Plains" technique. To test this hypothesis, Schultz not only used actual bison hide, but also obtained a finished product, going through each step in the process, from fleshing to physical manipulation.

In doing so, he approximated past behavior in each step at least to the degree that the hide was properly prepared for the following step and resulted in a useable product (Schultz 1989:64). Schultz's study is task-oriented and thus, much more actualistic than the four studies discussed above, but errs on other grounds. He sharply criticizes Brink and Keeley, as well as Semenov (1964), for dehairing hides by slipping the hair in the manner described above, although his criticism differs from mine. Schultz asserts that in the dehairing process the "epidermis" *must* be scraped off along with the hair in order for the finished hide to be soft (Schultz 1992:343). Of course, this is only true if the worker is using the "brain-tan" method where a softening agent is used to penetrate the fiber network of the raw pelt in order to lubricate and separate the fibers. In fact, for adequate penetration the grain layer must be removed as well as the thin keratinous layer of cells known as the epidermis. By his condemnation of the methods used by Brink, Keeley, and Semenov, Schultz is guilty of the same generalization made by these researchers and Vaughan as well. In assuming that the dry-scrape method of depilation approximates all past dehairing activities, he precludes "bark-tanning" or any other method where the grain is left intact and imposes the Plains method of hide processing on people that may have used another.

Despite his stress on the importance of ethnographic analogy, an alternative end product Schultz overlooks for a bison hide on the Plains is the buffalo robe where processing is carried out with the hair, epidermis, and grain left intact. Plains people carried on an extensive trade in robes, at least historically (Krech 1999:138-142). There is little reason to doubt that they manufactured robes prehistorically as well, for their own use and for trade (Creel 1991). Another product Schultz fails to address is rawhide, which can be manufactured by either method of depilation. Although I do not know which method prehistoric people preferred, there is an obvious difference between the two in resulting surface texture, stiffness, thickness, and in addition, dehairing with the grain left intact is less labor intensive than removing the grain along with the hair.

Further, I disagree with Schultz's four-stage model because he only includes smoking as an optional step. As discussed in Chapter II of this thesis, he is perhaps justified in excluding smoking as a necessary step in Plains hide processing, but because other environmental situations may require it and because it effects such a profound change in the pelt's characteristics, I believe it should be included in any model of "brain-tanning." Another source of confusion is in Schultz's journal article where he states that, contrary to Brink, he scraped dry hides in his experimentation (Schultz 1993:345). Yet, in his description of his experiments found in his thesis, he states: "The hafted endscraper proved to be an effective tool for the removal of the hair and the epidermis on a wet hide" (Schultz 1989:55). He further contends that hair will not slip from a dry hide (Schultz 1993:345). The problem here is that that the hide can be dried, but it may not stay dry due to humidity. Furthermore, the hide may appear dry, but again, due to humidity it may be damp enough to damage it. I once fleshed a bison hide, completely dried it, and stored it still laced in the frame, in a barn. In a year's time with varying periods of humidity and weather conditions, upon inspection the hair slipped and fell out from merely rubbing my hand over it, although the hide was indeed dry at the particular time I inspected it.

Summary and Conclusion

It is obvious from the preceding discussion that the process of hide working as practiced by North American indigenous people, or any prehistoric people for that matter, is rather poorly understood. Use-wear analysts and experimenters have not reflected past hide working behavior as well as they might have because of this lack of understanding, and as a result, perhaps are missing information or misconstruing information available in the archaeological record that might help to better interpret tool function. With a basic understanding of hide processing, experiments as well as terminology could become more standardized, thus reducing the confusion illustrated by the examples discussed in this chapter and allowing for comparison between functional studies.

This misunderstanding has resulted largely from attempting to compare different steps within a given method as in Hayden's study, or different methods within the hide working process, as in Keeley's or Vaughan's work. Further, when utilizing ethnographic accounts to study the hide working activities of people of a certain area as in Schultz's study, we must recognize that each generally describes a particular group of people manufacturing one type of hide product at a particular place and time as seen by one individual ethnographer. In order to standardize functional analyses, it must be understood that there are alternative hide products and alternative hide working methods even among similar cultural groups and animal species. Considering bison for example, Schultz (1989,1992) experimented with manufacturing hair-off leather, but robes and rawhide must also be considered. Furthermore, bison hide working methods cannot be directly compared to working deer, caribou, or sealskins. Researchers need to recognize the danger of comparing the work of different cultures on various species across space and time when conducting and reporting hide working experiments.

CHAPTER V

USE AND ANALYSIS OF THE TOOLS

This chapter describes a use-wear experiment similar to those recounted in the previous chapter in that it utilizes microscopy to describe and analyze the characteristics of the traces left on chipped stone endscrapers as a result of working hides. The work is similar to that done by Schultz (1989, 1993), in that I employ the elbow-hafted endscraper on bison hides and process the hides through use of the dry-scrape method discussed earlier. Schultz wanted to show that the primary bison hide processing tool on the Plains from historic times, the hafted endscraper, was very likely used in prehistoric times as well. He also wanted to show that the use-wear he obtained was different from that reported by previous experimenters because his methods were analogous to the ethnographic accounts he reviewed (Schultz 1989, 1993). The present experiment, however, seeks to answer a question that Brink posed in the hide working portion of his study, and that is whether or not individual steps in the process, namely fleshing and dehairing, will leave distinct use-wear characteristics on endscraper edges. Brink (1978) reported that there were no differences. As discussed in the previous chapter, he made no distinction between fleshing and hair scraping use-wears possibly because his methods were not analogous to what is reported ethnographically for bison hide processing on the Plains. The present work addresses this question using analogous methods, proceeding according to the model constructed in Chapter II and illustrated in Figure 6.

The Worked Material and the Tools

I have processed cowhides with the dry-scrape method using the elbow-shaped haft and both stone and steel bits. Although I had good success and cowhides are easily obtained, I felt that working bison hides would be more actualistic and a truer test of the hypothesis. Thus, the experiment was carried out on two bison hides, one of which was a winter hide taken from a two-year old bull that my colleagues and I had completely butchered with stone tools (Figure 8). The other was a late spring or summer cowhide purchased from a bison rancher near Caddo Mills, Texas. The hides had been frozen immediately after being removed from the animals and required a little more than a day in a barrel of water to thaw and hydrate properly so that when I commenced fleshing, they were wet, exhibiting the same characteristics as a freshly skinned hide. The winter hide measured roughly 1.8 m X 2 m and the summer hide 2 m X 2.2 m after trimming which they both required in order to fit them in the frames. They were laced with ¼ inch sisal rope and stretched as tightly as possible. The esthetic qualities of the winter hide determined that it would make a beautiful robe. Therefore, I performed the dehairing portion of the experiment only on the summer hide. Since the tools were not to be arbitrarily used beyond the point where they were sufficiently sharp for the task at hand, past experience led me to believe that dehairing one hide would create more than enough use-wear to study several endscrapers. Furthermore, processing hair-on winter hides into robes but dehairing summer hides for different types of leather products is both practical and consistent with the ethnographic accounts. Of course, both hides were fleshed.

William A. Dickens, a fine flint knapper and a graduate student from Texas A&M University, made the scraper bits of chert collected from Ft. Hood, Texas with the exception of scraper S6, which came from raw material at the Gault site near Salado, Texas. Measurements are given in Table 1. Length was measured as the greatest distance parallel to the long axis of the scraper, and width was measured as the greatest distance parallel to a line perpendicular to the long axis. Because edge angle changes along the bit and can be difficult to measure, it is given as the average of three measurements taken around the curve of the bit. Bit edge convexity was measured on polar co-ordinate graph paper and is used here to illustrate the “roundness” of the bit. It can be used to determine how much a scraper has been resharpened in the haft, assuming that the curve of the bit grows flatter as the edge is worked down. The scrapers were all worked unifacially and scraper S6 was made on a blade. They were mounted in one of two hard wood hafts each cut from a tree branch so that the distal portion of the haft was intersected by another branch, creating an “elbow” or “L”-shaped scraper. One was oak and measured 40 cm in length; the other was hackberry and measured 33 cm in length. Wet rawhide lacing, approximately 5-7 mm in width, served to bind the scraper bits into a notch cut in the distal end of each haft; nothing else was required. When the lacing dried, the bits proved to be extremely secure, standing up to the rigors of scraping hides with little or no movement.

Table 1. Metric Data and Number of Strokes per Scraper for Each Task for Experimental Scrapers.

Scraper	*S2*	*S3*	*S4*	S5	*S6*	*S7*	Average
Length in mm	69.5	85.0	74.5	73.0	84.5		77.3
Width in mm	51.0	50.1	40.5	50.0	49.5		48.2
Thickness in mm	19.5	17.9	10.8	15.1	14.0		15.5
Edge angle°	47	65	45	49	52		51.6
Bit edge convexity							
# Strokes fleshing	x	1300	3300	2700	x	x	2433.3
# Strokes dehairing	3000	x	x	x	3900	x	3450.0

Scraping the Hides

I began fleshing the winter hide by using the hafted endscraper to remove the larger masses of muscle and fat tissue as well as the membrane and smaller pieces of tissue. As I went through the fleshing process, the hide began to dry out, and before I had completed the work, it was relatively dry. As discussed in Chapter IV, this suggests that when fleshing a large hide such as bison, the worker scrapes both wet and dry hide. One would assume then that dry hide would be likely to leave the most recent use-wear characteristics on a fleshing tool except perhaps in cases where more than one person worked on one hide. In addition, complete fleshing, in other words, removing *all* the membrane seems more efficient on drier hide, but whether native people purposefully dried hides before fleshing is uncertain, especially in warm environments with high relative humidity. On drier hide, each stroke with the scraper averaged about 40-45 cm in length, removing a sort of “shaving” roughly 6-8 mm in width (See Figure 9).

In fleshing this hide, two scraper bits were used: S5 and S3. S5 completed some 2700 strokes before it became dull enough to need resharpening. At this point, I began using S3 and completed 1100 strokes, which concluded the fleshing of the winter hide.

I began fleshing the summer hide by using a toothed leg-bone flesher of the type discussed in Chapter II to remove the larger masses of muscle and fat tissue as well as some membrane. This tool was remarkably efficient at this particular task; nonetheless, the stone elbow scraper was required to remove *all* of the tissue and membrane. Since the use-wear on bone tools is beyond the scope of this thesis, I did not record the number of strokes with the leg-bone flesher, nor did I attempt to quantify any gains in efficiency or longevity conferred on the stone scrapers because of its use. It seemed, however, that I was able to scrape a larger area of the hide with a single stone scraper bit after initially using the leg-bone flesher.

After only 200 additional strokes, for a total of 1300, S3 was deemed too dull to continue and S4 completed fleshing the summer hide after 3300 strokes. This occurrence can likely be attributed to two things: sharpness of the edge and edge angle. Using the somewhat subjective test of passing my thumb across the edges, I was unable to make a determination of which scraper bit was actually sharper. However, the edge angle of S3 was approximately 65º, while that of S4 and S5 was 45º and 49º, respectively. Furthermore, slightly less than one centimeter broke away at the center of the bit, creating an edge angle of greater than 90°. Wilmsen (1968), in his study of Paleo-Indian tools surmised that endscrapers in the 46º-55º range were used in hide scraping, and my experience appears to support his findings (see Table 1). As explained in Chapter II, fleshing the hides renders them stable regarding decay and unwanted hair slippage, so long as they remain reasonably dry.

I then hafted scraper bits S2 and S6 and began to dehair the summer hide, which was now completely dry. Each stroke produced a shaving of hair and grain comparable in size to the shaving produced by fleshing dry hide (See Figure 5 and Figure 9). To my surprise, S2 and S6 completed 3000 and 3900 strokes respectively before becoming too dull to continue. I would have guessed that the scrapers used for dehairing would dull more quickly with fewer strokes than the scrapers used for fleshing, because this was generally the case when working with cowhides. I do not know whether this occurrence can be attributed to a physiological difference between *Bos Taurus* and *Bison bison bison*, differences in sharpness and edge angle of the scrapers used on the cowhides, time of year the hide was taken, or technique. In any case, the dehairing scrapers performed comparably with the fleshing scrapers of similar edge angle regarding number of strokes. However, it should also be noted that when adding the number of strokes required to flesh both hides the total is 7300, while the total of 6900 strokes did not complete dehairing the summer hide. This discrepancy can most likely be attributed to the dehairing scrapers frequently slipping over the long hair on the forequarters of the hide without removing the grain or the hair, therefore a good many strokes were counted that produced little or no work in terms of tissue removed. The set of fleshing scrapers on the average did work a somewhat larger area before becoming dull in spite of the performance of S3. The two hides together measured some 80,000 square cm, so the three fleshing scrapers averaged some 26,600 square cm, while the dehaired area of the summer hide measured roughly 36,000 square cm so that the dehairing scrapers averaged 18,000 square cm. This difference cannot be considered significant, however, because of the small sample size, and the use of the bone flesher on the summer hide must be taken into account.

In this work, I have stressed that the tools were used only to the point of losing efficiency and requiring resharpening. I realize that this point may be somewhat subjective from researcher to researcher, depending on the strength and technique of the individual. In addition, scraper attributes such as edge angle and sharpness should be controlled for. However, this method of deciding when to stop and collect the use-wear data makes more sense than using the scrapers for some arbitrary number of strokes or minutes. Once the scrapers were determined too dull to continue efficiently, each was unhafted, measured, and placed in plastic bags to await the analysis phase of the experiment.

Analysis

I began the analysis by examining each tool with the naked eye and noting any edge damage. The subsequent microwear analysis was carried out using two Leica microscopes, representing both the “low-power” and “high-power” approaches described earlier. The “low-power” was provided by a motorized Leica MZ 12.5 stereomicroscope equipped with a 1.6x objective and 10x oculars. Along with a stepless .8 to 10.0 zoom and the motorized focus capable of both fine and coarse adjustments, the microscope afforded clear, sharp images in a seamless range of 12.8 to 160 magnifications. Lighting was furnished by a KL 1500 LCD cold light source with flexible light guides and stepless electronic and mechanical adjustments controlling intensity and mechanical aperture, respectively. Images were captured using a Cool SNAP-Pro camera made by Media Cybernetics, which was interchangeable between the two microscopes.

A Leica DMLA compound microscope, initially fitted with 10x, 20x, and 40x objectives along with 10x oculars, enabled the "high-power" portion of the analysis to proceed with 100x, 200x, and 400x viewing capabilities. However, some modifications were necessary. This microscope was designed to view objects primarily under slides along with other relatively thin objects. Its stage does not have the appropriate depth to accommodate the vast majority of stone tools if one wants to view the edges, an extremely important attribute in the case of endscrapers. In order to address this problem, two more objectives, shorter in length but having magnifications of 20x and 50x were added to the microscope resulting in 200x and 500x viewing capabilities. It was soon discovered, however, that this did not add nearly enough depth to solve the dilemma. With the help of the Leica technician who installed the equipment, we found that the only way to obtain the needed space was to remove a portion of the reflective apparatus from underneath the stage. The scraper could then be positioned on a lower "platform" and pass through the light opening in the stage, thus placing the bit above the stage and directly under the objectives. The analyst must exercise a great deal of caution when changing objectives because this procedure is motor-driven and, with the specimen extending above the stage, could easily result in a damaged objective and/or specimen. Another inconvenience is that the analyst must control the “x” and “y” axis movements by hand, which can be tedious when viewing an object at 500 diameters. In any case, the benefits far outweigh the difficulties.

Acquiring images with the proper depth of field has always been difficult when attempting to achieve clear, distinct images, especially at higher magnifications. Levi-Sala describes the problem in this way. “Furthermore, the limited depth of field in the optical microscope is responsible for the fact that small differences in the orientation of the piece or plane of focus can affect the appearance of a feature and small movements of the focusing knob can show features which can mislead the human eye” (Levi-Sala 1996:65). The Image Pro and In-focus 1-60 software that interface with this camera-microscope setup has all but eliminated this problem. The analyst chooses a top and bottom point of the specimen in view, which sets the vertical limits of the image to be in focus, and in addition, chooses the number of in-focus images the camera will capture between these two points. The vertical distance is divided by the desired number of images. The microscope moves through the total vertical distance, stopping to let the camera focus at each division and acquire an image. The captured images are played back on the monitor screen as a sequence, which can then be combined into a composite image having the appropriate depth of field. This system affords clearer, sharper images than were before possible, especially at 50 and greater magnifications. Nuances of light, shadow, and color become visible, combining to create an image whose features are more easily identifiable, and that, in general, looks more “real.” Features of interest can be seen in context and in relation to other features and conditions on the surface of the tool. In addition, it saves time that the analyst would otherwise spend searching for a point exhibiting use-wear that was also flat enough in topography to render an image containing more than a small slice of which is in focus.

As in Kay’s Wilson Leonard study, the experimental tools in this study were not cleaned with acids nor washed with detergents, but the bits were thoroughly wiped with alcohol via a cotton ball (Kay 1998:746). The tools were scanned in the range of 12x to 25x to determine the presence and location of rounding, polish, and striations, and to examine microscars more closely. Although in general, use-wear characteristics were observed all along the curve of the bit, the most intense wear seemed to cluster in the center and about half way between the center and the end of the bit either left or right of center. This phenomenon is more than likely a reflection of how the hafted tools were held relative to the hides. The area of contact between the bit and the hide is relatively small, even though hide is considered a relatively soft material. As related above, each stroke with the scraper removed a strip of material with an average width of 6-8 mm. It is natural to begin scraping by using the center of the bit. However, once the center portion becomes dull and inefficient, it is also natural for the worker to slightly turn the tool in the hand to take advantage of a sharper area and continue to scrape instead of stopping at this point to retouch the tool. The amount and direction the scraper is turned in the hand is dictated by ergonomics and possibly handedness. There is no hard evidence supporting the differentiation of handedness through the position of edge wear on endscraper bits. I only mention it because interestingly enough, the person who helped me scrape the hides is right-handed and I am left-handed. It was noted that we turned the scrapers in opposite directions when the centers became worn.

When features of interest were found, they were recorded as digital images (see Appendix). Regarding microscars and edge damage, there is minimal evidence that one can attribute to use except for occasional clusters of micro-scars with feathered and half-moon terminations also known as spontaneous retouch and the occasional step scar. This is consistent with the fact that hide is not a hard material. There is one exception seen in Plate 4A, however, that occurs in the very center of the bit on S3 where there was a small projection. The most distal portion of this projection is obliterated by a series of step fracture scars that undercut the bit, creating an edge angle of greater than 90°. These flake scars are not as heavily rounded as those are on the remainder of S3. In general, flake scars attributed both to use and manufacture are heavily worn, with smoothed and rounded terminations and edges, and in many cases, are almost obliterated as seen on S6 used for dehairing (Plate 7). On both S6 and S4, a dehairing and a fleshing tool respectively, there is a considerable amount of rounding, which occurs not only on the high points of the tool's topography, such as the aforementioned flake scar arrises and the edges of step-fracture terminations, but also on the very edge of the bit (See Plate 5 and Plate 7).

There are also groups of linear indicators, which can be differentiated by appearance into several types. Some appear to be true striations or actual scratches in the surface of the rock, having width and depth likely caused by small particles of rock that are broken loose and dragged across the surface (See for example Plate 6E, F and Plate 7D). On S2, a dehairing scraper, they appear to be thin streaks of polish (Plate 3A, B). Being dragged across the surface by the action of the tool, the often highly polished rock particles, as well as what are possibly hide particles, collect along step-fracture terminations on both scraper types where linear indicators stop (Plate 6C, D). In some instances, however, the line of travel of the linear indicators is only interrupted at the step-fracture termination. They negotiate the change in elevation and continue for some distance past; again attesting to the fact that hide is a relatively non-rigid material. On S3, a fleshing tool, directional abrasion can be seen obliterating flake scar hackles (Plate 4E). As one would expect, the experimental scrapers possess striations and other linear indicators perpendicular to the tool edge, in keeping with the fact that these phenomena are reliable signs of tool direction. Sometimes what appear to be striations are actually hackles or a sequence of ripples in the surface. They look like streaks of polish because they are higher than the surrounding surface and thus will be polished first regardless of the tool direction. This is well illustrated in Plate 6E.

The step-fracture terminations on both types of scraper often have cracks or crevices underneath them where the flake separated, but did not entirely break away from the parent rock (Cotterell and Kamminga 1979:106; Lawrence 1979:117). An example is shown on S6 in the right upper portion of Plate 7C. The proximal portions of these flakes have broken away in the flaking process, leaving the distal portion attached only by what should have been the distal edge of the flake. The result is a remnant flake having the abrupt wall of a step-fracture termination, which acts to stop debris from being moved across the surface of the rock, along with a micro-crevice, which is able to trap debris that may be forced underneath it. In Plate 7E and 7F, rock particles and other debris can be seen at the edge and just underneath the remnant flake, which suggests that perhaps organic material could be forced under these minute overhangs and microscopic crevices and become trapped. Kay notes the occurrence of blood residue at step fractures on experimental Clovis points (Kay 1996:320-323). Organic material may possibly be preserved for a very long time given the right depositional environment. This phenomenon is also depicted on S5 in Plate 6C and 6D and is found on both fleshing and dehairing scrapers.

Within the range of 12 to 160 diameters, not only can the presence and location of polish be determined, but its characteristics can be viewed as well. Further examination and recording of polish characteristics was carried out at 100, 200, and 500 diameters using the DMLA. As discussed in Chapter III, Kay described two types of polish: abrasive and additive (Kay 1998:752-758). As seen in the images in the Appendix, several “types” of polish can be distinguished, again based on appearance. It may be the case, however, that the different types are degrees of either abrasive or additive polish. Plate 7C and 7D depicts S6 with a thin, translucent polish associated with directional abrasion that would seem to correspond to Kay’s abrasive polish. Regarding its appearance at lower magnifications, abrasive polish depicts the *condition* of the modified surface. In other words, the surface has been smoothed by the removal of surficial asperities and is therefore able to reflect light (Levi-Sala 1996:4). The surface gives the perception of a polished condition (Plate 7C, D). Higher magnification reveals microscopic rock particles that were broken loose and dragged across the surface as in Plate 3D. Also in Plate 3D, there is another manifestation of polish more solid and opaque in appearance, which leads me to associate it with Kay's "smooth abrasive" polish given the fact that it has striae in association and occurs on well-rounded step scar terminations (Kay 1998:752-756). At 160 diameters, it masks both the color and microtopography of the sample, which implies that either the surface texture has been smoothed away and so reflects light, or the polish is additive and lies on top of the microtopography, covering it.

Yet another depiction of a distinct polish, shown on fleshing scraper S4 in a sequence of images (Plate 5E-L), seems more like Kay's description of additive, or depositional polish. It appears to have thickness, and yet it is very clear, revealing the color and texture of the rock below it. At the risk of giving an overly subjective description, it looks very much like a thick lacquer was poured over the surface. It grades into a bright, more opaque polish, which completely masks the color and texture of the tool surface. Plate 6H-6J illustrates a relatively broad streak of this opaque polish ending at a step-fracture termination on fleshing scraper S5. It does not appear as thickly formed as that on S4 in that the texture of the rock can be seen.

There is another bright feature often visible on the bit of these scrapers that I am hesitant to call polish. It is very similar to the thick, apparently depositional, polish that I just described; however, it is appears crystalline rather than smooth and lacquer-like in appearance. These features are often located at step-fracture terminations much like the rock particles and other debris described earlier (See Plate 15L). Bright filaments that appear to be extruded from the surface often accompany it. Kay describes bright filaments that appear on the trailing edge of additive polish, interpreting them as part of the crystallization of the inorganic material of which the polish is hypothetically composed (Kay 1998:756-758). Using 12x magnification to view a patch of the "deposit," I was able to bring the sharpened end of a toothpick to bear, gently flecking it away from the surface, whereupon, it crumbled into smaller particles. The crumbled particles were not dry or dust-like, but on the other hand appeared damp, clinging to the end of the toothpick. At this point, I inferred that these features were probably either some form of contaminant or an organic deposit resulting from the recent use of the scrapers on hides and were not likely to be found on archaeological scrapers. Therefore, I attached little importance to them.

Relating Polish Attributes to Their Causal Factors

Given the small sample of these experimental endscrapers, one is hard put to conclude with statistical certainty whether or not the tasks of fleshing and dehairing bison hides can be distinguished by their traces of use-wear. However, from the characteristics observed on the scraper bits and documented in the microscopic images discussed in this chapter, and in light of the information presented in the studies of both Kay (1998) and Levi-Sala (1996), there are things worth noting, especially concerning polish.

Of all the use-wear attributes found on the experimental scrapers, namely edge damage, edge rounding, linear indicators, and polish, the attribute that exhibits the most variability is polish. Levi-Sala contends that the development of polish is sequential and a matter of degree. Her experiments were designed to show that polish development is dependent on the characteristics of the rock, the rigidity of the worked material, the presence of a liquid medium, the presence and coarseness of an abrasive, the load on the tool and the duration of the work (Levi-Sala 1996:67-70). I would add that it is also dependent on edge angle and the initial keenness of the bit. Polish found on the experimental scrapers exhibited various degrees of the following attributes: location, amount (area) and type (continuous or scattered) of coverage, thickness or depth, texture, brightness, color, density, and transparency. Grouping the images according to fleshing (S3, S4, and S5) and dehairing (S2 and S6) results in the conclusion that no one "type" of polish alone corresponds specifically to one of these tasks.

The Fleshing Scrapers. In her hide experiments, Levi-Sala found that polish developed more quickly on damp hide than on dry hide, contrary to Brink's findings; and that water was not necessarily the damping agent (Brink 1978:100-102; Levi-Sala 1996:67-70). When fleshing is begun, the green hide is damp, not only with water, but with fats and oils as well. Therefore, one would expect to see a greater amount of more highly developed polish on the fleshing scrapers than on the dehairing scrapers. Furthermore, the greatest and most rapid development of polish occurs in the initial stages of the work, and polish that develops later on in the process when the hide dries is not likely to mask or efface the initial polish.

S3 has the least amount and the least developed polish of all the experimental scrapers, having areas with a relatively thin layer of the clear lacquer-like polish that I would compare to the beginnings of Kay's additive polish (Kay 1998:756-758). Actually, this comes as no surprise, since S3 saw the least amount of use, lasting for 1300 strokes before becoming too dull to continue. As stated earlier, this can likely be attributed to a rather steep edge angle of roughly 65º (greater than 90° in the center where there was also less rounding). The other two fleshing scrapers, S5 and S4, with edge angles of 49° and 45° respectively, were used for 2700 and 3300 strokes, respectively. This supports the hypothesis that duration of use influences the formation and development of polish.

The clear lacquer-like polish on S5 covers more area and is generally more developed than that on S3, although in places, it is relatively thin. Plate 6E shows one of the thin areas of polish in association with several rather broad streaks, which are darker than the surrounding polish and end in a step-fracture termination. However, these streaks do not indicate direction. These are hackles in a flake scar where there are bands of alternating topography, appearing as polish bands because the lower bands have not yet been polished. There are also two occurrences of the broad but thin streaks of bright opaque polish ending at step-fracture terminations described previously and shown in Plate 6H-J. On the other hand, Plate 6G shows a clear, thick, and very smooth polish over the surface of a flake remnant.

S4 has by far the greatest amount and the most highly developed polish. Virtually the whole bit is covered with the thick lacquer-like polish as well as the thick, smooth-surfaced opaque polish seen in Plate 5E-5J. The opaque polish shows up as very bright light under the microscope. Decreasing the light intensity dims the "hot spots" and facilitates the viewing and capture of images so that this polish appears white in the images. S4 was made from a rather grainy material having an abundance of quartzite and other inclusions, which is probably one primary reason that it exhibited such an extensive distribution of well-developed polish. Plate 5I shows the extruded crystallization filament described earlier, and Plate 5K shows clear polish in the background with a patch of the white polish partially overlaying an inclusion. S4 also received 3300 strokes fleshing the summer hide and began its use-life when the hide was damp. According to the list of factors influencing polish development drawn up in the previous section, the distinct polish on S4 was influenced by the duration of use, the characteristics of the rock, and the presence of a liquid medium.

The Dehairing Scrapers. Scraping the hair side of bison hides, using the dry-scrape method as was done in the present study, takes place after the hide is dry. Therefore, one would expect to find a smaller amount and distribution of polish as well as less developed polish. One might also expect that the location of polish would be more limited to the edge and to high points of the surface topography, since dry hide is much more rigid than damp hide, although it is still classed as a soft material. S6 exhibits areas of the abrasive polish Kay describes as lesser developed than the smooth abrasive polish, accompanied by striae, and located near the edge and on high flake arrises. One such location is illustrated in Plate 7C. The left side of this same image also shows the smooth abrasive polish, which Kay describes as better developed and associated with worn striae and heavily rounded edges (Kay 1998:752-756). Plate 7D shows the same area at higher magnification. At the top left edge of the long step-fracture termination near the top of Plate 7C, there is a small area of the lacquer-like additive polish. A facing view of this edge is shown in Plate 7E at a higher magnification. There is also additive polish located near the bit edge.

S2 also has extensive areas of the lesser-developed abrasive polish as illustrated by Plate 3B. In addition, at the left of Plate 3C, one can see examples of what were described in the previous section as a bright, loosely bonded substance collecting at step-fracture terminations. It has polish associated with it and often appears to lie on top of the polish. An area of a more developed polish, along with worn striae can be seen on the left in Plate 3A. In Plate 3D, areas of polish are beginning to mask the rock surface. An example of the clear polish can be seen developing on two overlapping flake remnants at the very edge of the bit in Plate 3E and F. Although it overlays a shallow step-fracture termination and is just beginning to mask the color of the rock below, the polish is rather thin, reflecting the rock's texture. In Plate 3G, it overhangs the edge of a deeper flake scar termination. S2 also exhibits a small opaque depositional feature on the bit edge and is depicted in Plate 3I and J.

Conclusions

I reiterate here the idea stated at the beginning of the foregoing discussion. From the data gathered through the microscopic analysis of this small sample of endscrapers, it would indeed be difficult to distinguish between an assemblage of scrapers from a particular archaeological site, those used only for fleshing and those used only for dehairing hides, with any degree of certainty. Three of the four attributes of use-wear considered here: edge damage, edge rounding, and striations on both sets of scrapers conform well to what would be expected from general use on hides and express relatively little variability. However, close observation of the different attributes of polish integrated with the factors affecting its development provides grounds for splitting the assemblage into two groups. Again, polish attributes are: location, amount and type of coverage, thickness, texture, brightness, color saturation, density, and transparency. Factors affecting the development of polish are: the characteristics of the rock, the rigidity of the worked material, the presence of a liquid medium, the presence and coarseness of an abrasive material, the load on the tool, the duration of the work, the edge angle, and the initial keenness of the edge.

One can tell from the list of attributes that dividing these scrapers into two task-based groups is not done strictly based on presence or absence, but on degree as well. There were only two manifestations of the observed polish characteristics not common to both groups, and as one might expect, these were the two extremes. I did not find the lesser-developed abrasive polish on the fleshing scrapers, nor did I find the smooth, thick, opaque polish on the dehairing scrapers. The fleshing scrapers were undoubtedly used long enough to obliterate the abrasive polish. More importantly, their use on an initially damp hide caused rapid development of the polish, which would likewise obliterate the appearance of any initial abrasive polish. Similarly, I found none of the thick, opaque additive polish on the dehairing scrapers, although the duration and intensity of use was comparable to that of the fleshing scrapers. This is presumably because they were used on *dry* hide. Furthermore, fleshing scraper S4 had the highest level of polish development in either group most likely because of the characteristics of the rock. The material from which S4 was made contained an abundance of quartz, which aided in the rapid development of the advanced stage of polish found on its surface.

In comparing the attributes of polish, the images show that the fleshing scrapers, with the exception of S3, possessed a higher degree of thickness, density, and brightness of polish. Polish covered more surface area and there was more smooth textured clear polish, which graded into the smooth opaque polish on S4. Of the factors influencing polish development, the presence of a liquid medium in the form of a damp hide appears to be the factor that allows the scrapers to be categorized. However, the *extreme* polish development on S4 can be attributed to the characteristics of the material from which it was made more so than the characteristics of the hide. Likewise, the paucity of polish on S3 is undoubtedly a function of its edge angle and duration of use more so than a function of the contact material.

This suggests that we may well be able to separate the use-wear left by these two primary hide working tasks in other scraper assemblages because recognizable differences in the attributes of polish have been affected by the factors responsible for their development within the parameters of the hide-working analog constructed here and illustrated in Figure 6. In other words, it may be possible to distinguish fleshing from dehairing because fleshing is carried out initially on damp hide, while dehairing is done on dry hide. Polish develops quicker on damp hide. Therefore, fleshing should be represented by more highly developed polish that forms quicker. The first step is to conduct additional actualistic and product-oriented hide working experiments, maintaining a well-researched analog. This must be followed by analysis of many more experimental scrapers to see if a distinction can be made with any statistical confidence. If it can, then the study should employ blind tests so that the analyst acquires skill in interpreting presence, degree, and location of the use-wear. More actualistic hide-working experiments with resharpening involved will provide a more fine-grained quantitative idea of how many hides a scraper is capable of working according to the model constructed in this thesis. Finally this knowledge can be used as another line of evidence aiding in the inference of prehistoric behavior from the evidence found on stone tools in archaeological assemblages.

CHAPTER VI

THE GAULT ENDSCRAPERS

This chapter reports the use-wear characteristics found on the edges of an assemblage of archaeological endscrapers from the Gault site. Comparing these characteristics to those found on the edges of the experimental scrapers will determine if the use-wear from the two assemblages is similar or not and allow inferences to be made regarding the function of the Gault endscrapers. The same methods used to study the experimental hide scrapers are utilized in this chapter.

These endscrapers were recovered during the 2000 TAMU field school from the Clovis component of a large site in central Texas known as the Gault site. It is situated in western Bell County on the headwaters of Buttermilk Creek at the boundary of the Blackland Prairie and the Llano Uplift. The advantages of living within such an ecotone resulted in the occupation of the site virtually the entire Holocene. The Gault site contains the greatest density of Clovis artifacts in North America. They occur on a buried gravel bar and in pond clays and overlying floodplain deposits. The Clovis material is capped by a weak soil and separated from later cultural deposits by an erosional unconformity (Waters and Shafer 2002).

The assemblage makes up a discrete tool set for the most part. Twelve in number, the scrapers are small in size and made of chert common to the central Texas area. Generally, they are morphologically similar, possess a distinct hafting element and steeply beveled bits, and are apparently at the end of their use-life. Determined by stratigraphy to be Clovis in age, they entered the archaeological record in a fairly tight cluster. Of the 22 square meter units excavated, seven contained the twelve scrapers, and one unit contained five. All were found in Levels 17-24, which, being five cm levels, translates to 40 cm or less than sixteen inches of vertical deposit. In geological context, all were found in two consecutive geologic units, 3a and 3b, which were determined to be a Clovis clay and a Clovis soil, respectively. A perusal of the level forms indicates lithic material recovered along with the scrapers includes blades and blade fragments, bifaces and biface fragments, debitage flakes including overshot flakes, cores, and point fragments. Non-lithic materials recovered are animal bone fragments and ocher.

Lithic Analysis

Before any comparison with the experimental scrapers took place, the Gault scrapers were analyzed as a data set. In this discussion, tools are referred to by their bag number because it is a simple way of identifying them and because provenience and other information can be accessed from this number as well. In addition, the discussion loosely follows the coding form developed for these scrapers, a copy of which can be found in the Appendix.

Ten of the twelve endscrapers are complete and two are broken. Scraper G299 has a transverse snap or bending fracture, which removed the proximal end, leaving the medial-distal portion of the tool. When and how this fracture occurred is hard to say, but it is doubtful that it occurred from use, especially if the tool was hafted, because the fractured area would have been securely fixed in the haft. It could have been a post-depositional occurrence. The proximal portion of scraper G288EEE is broken with an oblique perverse fracture that took off part of a fairly pronounced bulb of percussion. This fracture likewise could have been post-depositional. It is not likely to have occurred from use.

All the scrapers, as mentioned previously, are made of chert common to the Central Texas area. Four are heavily iron-stained and the remainder range in color from a mottled gray to a mottled tan. Five tools possess cortex, ranging in amount from only the platform to over 70% of the dorsal surface, and five have patina also varying in extent as well as stage of formation.

In plan view, five scrapers are expanding distally; two are parallel; three are parallel to slightly expanding; and two are irregular. In cross section, ten have a flat to slightly convex ventral side together with a dorsal ridge, or raised area, running longitudinally at least part of the way from proximal to distal end. In longitudinal section, ten scrapers have the slightly concave ventral side that gives the characteristic downward curving bit seen on endscrapers across time and space.

Seven of the twelve tools possess the platforms struck in their manufacture, and three are at an angle to a centerline drawn longitudinally from the proximal to the distal end. Four of the seven have plain flat platforms and, of the remainder, two platforms are faceted and one is dihedral. All seven platforms are lipped. Average length of platform is 6.71 mm and average width is 3.18 mm. Six of these seven have a diffuse bulb.

Nine of the scrapers possess spurs on one or both sides. Spurs are small lateral projections that occur on either side of the bit and sometimes both. When the dorsal face of the scraper is observed in plan view, they appear as lateral extensions of the bit, projecting past the hafting element of the tool. They are generally considered to be a Paleo-Indian marker. Collins makes a very reasonable argument that spurs are more than likely a result of refurbishing the edge and sharpening the scrapers while in the haft. Following this model, the bit portion would initially be wider than the hafting element and each time the scraper length is reduced through resharpening, the bit edge recedes nearer to the haft. After the final resharpening and use episode, the narrow "spurs" are all that remain of the lateral portions of the original bit (Collins 1999:28). The present analysis seeks to determine if the spurs were used, and if so, how they were used.

Metric information is recorded in Table 2. It should be noted that, as a whole, the Gault scrapers are significantly smaller than the experimental scrapers. This is because the use-wear experiment was already underway when the Gault scrapers were being excavated. However, since the main concern of this thesis is the microscopic wear on the bits, it was felt that the comparison would be of value regardless of the size difference. In addition, there is not much difference in the average width to length ratio between the Gault scrapers and the experimental scrapers. These values are .6796 and .6485, respectively. Despite their diminutive size, it is conceivable that the Gault scrapers could be used to scrape bison hides effectively if they were sharp and properly hafted. As discussed in Chapter II, only a small arc of the curved bit comes in contact with the hide at any given time during the stroke, assuming that the hide is fairly taut.

Table 2. Metric Data for Gault Scrapers.

Scraper	*188*	*192B*	*227*	*248A*	*301NNN*	*311*	*319*	*364*	*417*	*172*	*288EEE*	*299*	*Avg*
Length in mm	28.7	41.2	29.8	44.6	66.5	38.0	36.9	26	44.6	57	51.9	25.3	40.9
Width in mm	23.5/ 28.7	25.5/ 28.0	21.3/ 25.1	33.1/ 38.3	26.8/ 44.8	23.4/ 32.0	25.5/ 29.7	21.8/ 24.4	23.3/ 31.2	33.3	28.9	22.6	25.8/ 31.4
Thickness in mm	5.3	6.2	5.6	6.0	7.2	6.7	5.8	3.5	7.7	12.6	7.1	5.6	6.6
Edge angle°	90+	57	95	80	75	75	90	70	85	80	63	75	77.9
Bit edge convexity	61.3	30.5	35.6	36.0	64	56.4	51.1	35.8	56	78	25.3	25	46.2

Functional Analysis

Consistent with other tool groups observed at the site, the Gault scrapers are extremely worn and appear to be near the end of their use-life. Their last cycle of retouch left them with edge angles averaging some 80°. The center portion of the bit edge is often undercut with series of step-fractures and crushing creating an edge angle upwards of 115°, clearly of not much use for hide scraping. However, such steep edges could be used for staking hides, the softening process described in Chapter II and cited by Hayden in his study of Eskimo scrapers discussed here in Chapter III. Frison acknowledges this as well; explaining that by using a blunt bit with a high edge angle, intense pressure can be exerted against the hide without damaging it (Frison 1987:249). The problem is that the use of such small scrapers for staking a hide would be extremely tedious and inefficient, especially since almost any larger, heavier tool would be more effective, whether wood, stone, or bone.

Group A: Bits. This assemblage can be divided, based on morphology, into three groups. The largest contains nine scrapers. The deciding characteristic for membership in this group is the presence of one or both spurs. Another characteristic binding the spurred scrapers together is the fact that they are all unifacial tools with definite, although differently shaped, hafting elements. Three are sub-parallel and the other six converge toward the proximal end. One scraper from the sub-parallel group and two from the converging group are heavily notched on the lateral edges.

Regarding wear on the bits, microscopy reveals the severely battered edges previously discussed in the introduction to this section. Plates 12A, 11A, 18A-C, and

19A, B illustrate microflaking typically found near the bit edge and most especially in the center of the bits. On scrapers G188, G227, G301NNN, and G417 (Plates 34A and B, 12A, 16A and B, 20A) the damage has undercut the edge resulting in edge angles of greater than 90° and a flattened area visible in the center of the bit in plan view. Series of stacked step-fracture terminations and "crushing" of the immediate edge create this damage, impinging on and in many cases obliterating, older rounded and worn retouch scars. This area of the bit edge is generally rounded though in some cases it is not, even though the immediate edge and the flake scar arrises to the left and right of the center. Also present are remnant flakes that are still attached to the tool's surface. Remnant flakes were observed on the experimental scrapers and were described in the previous chapter where it was shown that debris could become trapped underneath them.

Microflaking resulted in a rather asymmetric bit shape on scraper G248A, shown in Plate 2E and Plate13. Frison documents similarly shaped endscrapers at the Horner site (Frison 1987:246-248). Both spur tips are broken and missing, the one on the left by a force from the dorsal face, and the one on the right by a force from the ventral face. The result is two slightly concave edges at the end of each spur whose lengths measure five mm on the left and six mm on the right. Another concave area measuring 10 mm in length is situated between the center of the bit and the concave area on the right spur, creating a steeply beveled edge on the ventral face that projects out past the rounded outline of the remainder of the bit. The remainder displays the extremely battered microflaking in the center similar to the other scrapers. All the edges on G248A exhibit a fairly high degree of rounding, an example of which is seen in Plate 13.

Nearly all of the linear indicators found on the bits are situated perpendicular to the bit edge, and together with the fact that that there is almost no ventral wear, indicates that the tools were used in a similar manner and motion to the experimental scrapers. One exception is scraper G227, where the bit has faint linear indicators running both parallel and oblique to the bit edge (See Plates 12B, 20A, and 20D). Other exceptions are scrapers G319, which has a few small flake scars on the ventral side of the bit edge, and G192B, which has a series of rounded “1/2 moon” flakes or nibbling on a small flat portion of the left ventral side of the bit (Keeley 1980:24-25). This could indicate that the tool was used in more than one direction, or considering the paucity of evidence, it could simply be an indication of post-depositional edge damage.

Polish is present to some degree on all bit edges, especially at the immediate edge and topographical high points such as step scar terminations and the thin remnant flakes. Polish is conspicuous on remnant flakes because the space underneath them causes them to reflect light differently than the rest of the surface (Lawrence 1979:117). Generally, the stages of polish observed and described in the analysis of the experimental scrapers are represented on the Gault scrapers. Plates 11A-C show an example of heavy polish at step terminations near the bit and Plates 11C and 20C show depositional polish on remnant flakes along with filaments extruded from the surface. In the previous chapter, I described a bright, crystalline substance often accompanied by filaments and loosely bonded to the rock surface, surmising that it was in some way associated with only the modern experimental scrapers. However, it was also present in some degree on a majority of the Gault scrapers, despite the fact that they had initially been cleaned with warm water and a toothbrush, and some had been chemically cleaned due to calcium carbonate encrustation. In addition, I wiped them with a cotton ball soaked in alcohol as I had done the experimental scrapers. After discovering the presence of the substance, I rewashed some of the scrapers with soap and water (but without brushing them) to see what effect it would have. The substance is still present. Plates 10C, 17A and B, and 19A and B show examples.

Another specific manifestation of polish observed on both sets of scrapers is the broad but short streak of polish that ends abruptly at a step-scar termination. The streak is opaque, yet thin, revealing the texture of the rock beneath it. Previously seen on the experimental scraper S5 in Plate 6H-J, it can also be seen in Plate 20B and C and Plate 11E on the Gault scrapers. There is still another polish streak visible on scraper G417 near the bit that was *not* observed on the experimental scrapers. Shown in Plate 20E-G, the streak appears to be on fairly flat topography and turns back on itself as if it were smeared on with a paintbrush. A similar phenomenon occurs on scraperG188 and appears in Plate 10A-D in a sequence of images.

Group A: Spurs. Regardless of which theory one chooses to embrace as to how the spurs in Group A came to be, there can be no doubt that they functioned as tools. Nevertheless, as Collins argues, the fact that use-wear is present on the spurs does not necessarily support the idea of intentional production (Collins 1999:28). Holding to the notion that the spurs were formed as a result of sharpening in the haft, the ends of these spurs would have been used after the final resharpening and use cycle. The spurs could then have been used with no further preparation and without removing the tool from the haft. On the other hand, the scrapers could have just as well been removed from the haft and discarded before the spurs were utilized in order to free the haft for the installation of a new scraper. At any rate, all but one of the spurred scrapers in Group A exhibit unequivocal evidence of at least one use-wear attribute on the end of at least one spur.

Regarding edge damage and microflaking, the spurs display broken and flaked tips. In some cases the breaks are the result of bending forces applied from either the dorsal or ventral face. The resulting scars may have scalar or step scars imposed over them, or may simply exhibit edge rounding. As described for the bit, a series of step scars can produce an edge, or in this case a tip, with a "crushed" appearance. The reader is referred to Plates 10I, 19C, 19J, 20I, and 20K for examples. Generally, the microflake scars appear on the dorsal aspect of the spur. However, nine out of the fifteen spurs examined have some flaking on the ventral side, usually in the form of two or three shallow step fracture scars accompanied by heavy rounding. Plate 19E shows worn microflake scars along with polish on the left spur tip of scraper G364. Plate 12C and D depicts a scar left by a broken spur tip, revealing an apparently weathered surface. The missing left spur on scraper G188 was broken off due to a bending, or snap, fracture. The resulting scar covers almost half the left lateral edge. As seen in Plate 10G and H, the ventral edge of this large, flat snap-fracture scar bears linear indicators as well as rounding, indicating that the left side of the tool continued to be used. Further edge rounding can be seen in Plates 10J, 12B, 17D, 18A-C, 19C-H, and 20H-K.

Seven of the nine scrapers in Group A possess a notch just proximal to one or both spurs. A series of step-fracture scars that were struck from the dorsal face of the tool on some spurs and the ventral face on others created the notch, which is located at the junction of the base of the spur and the lateral edge. The ventral side of such a notch, exhibiting polish inside and a band of polish around the edge along with edge rounding, is shown in Plate 19I.

Linear indicators are rather common on the spur tips in Group A and may be oriented in different planes and directions, depending on the morphology of the spur tip. Plate 18D-F (see also Plate 2J) depicts a spur tip that has not been truncated by a snap fracture or other attrition and is therefore somewhat flat in cross-section. In such a case, the linear indicators may occur on the dorsal or ventral surface of the spur tip. Within this plane, they may be unidirectional and lie perpendicular, parallel, or oblique to the spur tip, or conversely, they may be multidirectional as in the case of scraper G192B and G417 illustrated in Plate 11F and Plate 20I. When the tip has been truncated, linear indicators may occur on the face of the spur tip, again running in variable directions. Plate 10J shows linear indicators on the face of an extremely rounded edge and in Plate 16D and E, they are situated on the flat surface of a snap fracture scar. In both images, they are parallel to the long side.

Polish is another prevalent attribute associated with the spurs and generally has the characteristics described in this work and by Kay (1998:752-756) as additive, or depositional. It ranges in appearance from clear and lacquer-like to smooth opaque, obscuring the texture of the rock below it. It also varies in extent and amount of coverage. The sequence of images in Plate 10K-N illustrates in increasing magnifications, the lacquer-like polish that covers the entire right spur tip of scraper

G188. Plate 18E and F shows a nearly opaque form that does not mask the rock's texture, and furthermore, is not invasive, but only occurs as a band along the edge. Plate 19D-H is a sequence of images depicting varying forms of polish on the spurs of one scraper. Plate 19D shows a clear polish essentially covering the dorsal aspect of the left spur of scraper G364; Plate 19E shows a clear polish grading into a band of opaque polish along the proximal edge of the left spur; and Plate 19G and H shows a highly developed clear-to-opaque polish enveloping the right spur. The right spur tip of scraper G248A has a distinct polish boundary between the clear and opaque polish seen in Plate 13F. The loosely bonded material described earlier manifests an ample presence on portions of the spurs as well.

Group A: Lateral Edges. Of the nine scrapers relegated to Group A, five have lateral edges that are expanding, three are parallel to slightly expanding, and one is parallel in plan view. Most of the flaking that shaped the lateral edges is unifacial, occurring on the dorsal face of the scraper and leaving the edges steeply retouched. There are small shallow flakes on the ventral sides however, and these may be either use-wear or the result of raking the edge undoubtedly for the purpose of strengthening it. In some instances, it seems that an attempt was made to hold the edges fairly straight as on scrapers G192B and G319. Conversely, large deep flakes or a series of flakes taken off both the dorsal and ventral sides resulted in notched sinuous lateral edges as on scrapers G301NNN, G227, or G417. Plate 12K shows a stack of step scar terminations in a portion of a notch on the lateral edge of G227, and Plate 12L shows rounding in the same notch, but inland from the edge. Rounded step scars along a lateral edge are also depicted in Plate 18H. Plate 17E and F shows a sequence of images depicting a large step scar with a jagged termination outline. This flake actually shaped the proximal edge of the left spur.

Directional indicators are oriented in various directions to the edge. As seen in Plate 12I and J, they run oblique to the edge and in Plate 13D they are oblique but run in opposite directions, trending toward both proximal and distal ends. In Plates 16F and 17F, they are multi-directional in orientation, and Plate 20N and O shows linear indicators running both perpendicular and parallel to the edge.

Polish occurs on the lateral edges as the abrasive polish described by Kay (1998:752-756.) and seen in Plate 13C. An example of the smooth abrasive polish is seen in Plate 18H. The depositional polish in the clear lacquer-like form along with extrusive extensions and filaments is illustrated in Plate 20L on the dorsal aspect of the left lateral edge of scraper G417. Plate 20M shows the ventral side of the same area with clear polish grading into opaque as well as particles of the loosely bonded crystalline material discussed above. Plate 12E-H shows a band of clear polish along the left lateral edge of scraper G227 in a sequence of increasing magnifications. Plate 11G and H shows a similar band of opaque polish along the left lateral edge of scraper G192B. As a final example of polish on the lateral edges, Plate 13D shows two small areas of opaque polish with linear indicators on the right lateral edge of scraper G248A.

Group B: Bits. One scraper, G299, represents group B. The criteria setting this scraper apart is its lack of spurs, its lack of steeply beveled lateral edges and/or notches, and the fact that it is incomplete, the proximal portion broken and missing due to a snap fracture. In addition, the left lateral edge is missing due also to a snap fracture.

The bit, however, is very much like the bits in Group A, being very steep and heavily battered in the center, where step fractures scars intrude on the larger, rounded retouch scars that shaped the bit. The immediate bit edge in this area is rounded also. These characteristics as well as clear polish can be seen in Plate 15B. Plate 15A likewise shows worn, rounded flake scars, a rounded edge, linear indicators running in multiple directions, and clear polish with areas of heavier development.

Group B: Lateral Edges. The left lateral edge is made up of a flat snap fracture surface, which is mostly covered with what is likely calcium carbonate, so that little can be said about it regarding use-wear. The right side feathers out to a very thin lateral edge bearing groups of feather terminated micro-flake scars alternating on both the dorsal and ventral faces except for the proximal 3.5 mm, which is truncated by the snap fracture. This area exhibits steep retouch that was initiated on the ventral edge, yet the ventral edge is battered to the point of being undercut as shown in Plate 15C and D. A good portion of scraper G299 is covered with patina that appears heavier on the ventral side. The images in Plate 15E and F depict the patina in increasing magnifications.

Group C: Bits. The two tools making up this group are set apart by their morphological characteristics, by reason of which, one might hesitate to call them scrapers. The bit of scraper G288EEE is so very thin that one wonders how it escaped intact if it was hafted and used as a scraper. Furthermore, hafting either of the tools in this group would be problematic since neither one of them have a formal hafting element, especially scraper G172, on which the ventral surface does not lie in a plane, but is badly skewed. This makes it difficult to keep the tool from rocking in the haft, which would make scraping at the very least, less efficient than the other scrapers in this assemblage. Nonetheless, both tools posses a distal end that is shaped very similarly to the other scraper bits in the assemblage.

The bit of G172 is rather square in plan view and exhibits similar flaking to other scraper bits in terms of a steep battered edge and stacked step fracture scars that cover older, larger retouch scars, along with microflake scars at the immediate edge. These characteristics can be seen in Plate 9A-C. All bit flaking is initiated from the ventral side of the bit. Scraper G288EEE is an iron-stained tool with a very thin bit edge. Worn and rounded retouch flakes define the thickness of the bit, running from the immediate edge to the dorsal face. Some areas of the immediate edge exhibit rounded and worn half-moon, or edge bite microflakes, while other areas such as projections, are battered and undercut with series of step fracture scars that truncate and flatten the projections. This can be seen in Plate 2F and Plate 14A and B.

Neither rounding nor linear indicators are visible on the bit of G172, while the bit of G288EEE exhibits rounding but no linear indicators. Polish is present intermittently along the bit of G172. It is present on the immediate edge becoming more invasive in certain areas. It is also apparent, along with directional indicators, on remnant flakes, certain ridges and step fracture scars, and the center undercut portion of the bit as seen in Plate 9D and E. Scraper G288EEE features a more highly developed polish throughout the total bit area than G172, although neither displays the development of polish generally seen on the other bits in the assemblage.

Group C: Lateral Edges. The right edge of G172 is nearly covered with a smooth white cortex. All flaking is on the dorsal aspect of the edge and consists of clusters of stacked step fracture scars that created four notches. The most proximal notch is adjacent to the striking platform and was likely made to isolate it and to strengthen the edge when the tool was manufactured. The left edge is thin and made up of half-moon scars. On the distal half of the left edge, the scars are large and occur on the dorsal face, while on the proximal half of the edge, the scars are smaller and occur on either face. As seen in Plate 9F, the high points of the microflake scar outline are often truncated or flattened in plan view.

The right edge of G288EEE is similar in thickness, curvature, and flaking to the left edge of G172. The flake scars on the right edge of G288EEE are nearly all very small, giving the edge a serrated look and feel. Microscopy reveals that these are half-moon flake scars that occur in small groups alternating at random on either the dorsal or ventral sides of the tool. As seen in Plate 14C and F, the outline of the high points are flattened and rounded as those on the left margin of G172. A long shallow notch resulting from a bending fracture takes up a good part of the left edge of G288EEE (see Plate 2F and Plate 14). This notch and the shape of the left side of the bit create a spur-like projection similar to those on the Group A scrapers. The projection has a single rounded half-moon scar on its dorsal face. The remainder of the left lateral edge is a straight section of half-moon edge bites similar to the right edge.

Linear indicators are not extremely well developed on the lateral edge of either tool. However, there are some examples to be seen in Plate 9H-J, L and M and Plate 14D and I-M. These generally trend parallel to the lateral edges. Plate 14K-M shows a flake scar on the right lateral edge of scraper G288EEE whose surface appears to be flattened and polished by abrasion. Random striae apparently caused by particles being dragged across the surface are clearly visible as well. Both tools display similar polish along edges as seen in Plate 9F and G and Plate 14G and H, but G288EEE also displays the clear depositional polish over nearly the entire surface, although it appears more developed along edges and other areas where microflaking and rounding occur.

Discussion and Conclusions

There has been some prior discussion concerning the size difference between the two assemblages of scrapers analyzed in this thesis. Two other differences are readily apparent. One is the fact that 75% of the Gault scrapers have spurs that exhibit use-wear attributes, and the other difference is the existence of use-wear attributes on lateral edges of the Gault scrapers. However, these differences do not affect the actual use of the bit as a scraping tool. Therefore, the use-wear characteristics of the bits are compared in the following section, which is in turn followed by a summation of the use-wear characteristics of the spurs and lateral edges.

Comparing Bits. Regarding flaking patterns, there are generally three sets of flake scars based on size and location in relation to the edge. Both assemblages possess the characteristic unifacial flaking associated with the manufacture and refurbishing of endscraper bits, where the length of the flake defines the thickness of the bit. The resulting flake scars make up the set whose terminations are furthest from the edge and are generally of the large scalar type with feathered terminations (Hayden 1979:133-135; Keeley 1980:24-25). Nearer the edge is the second set, which is made up of smaller scars with, feathered, but more often, step terminations that overlay the larger scars. On the immediate edge is the third set of flake scars, which frequently has micro-step scars and half-moon scars. The latter often occur on very thin edges and are nearly always accompanied by rounding. As noted above, there are a few ventral flakes on scrapers G319 and G192B from Gault.

One major difference between the two assemblages is in the amount of scarring. The Gault scrapers exhibit a heavier concentration of step-terminated scars, especially in the center of the bit where they often occur in a series or stack, resulting in undercutting and removal of a portion of the bit edge. On the other hand, the experimental scrapers have less scarring, and the scars that are present are considerably more rounded than those on the Gault scrapers. In addition, the bit edges are also more rounded on the experimental scrapers.

Linear indicators are often present and their orientation is always perpendicular to the edges of the bits of the experimental scrapers, regardless of whether they are scored into the rock surface by moving particles, or they are merely in the polish. The Gault bit edges do not indicate linear features as often, and the orientation of the features that are visible is more variable. Plate 19A shows linear indicators on the bit of G364 and there is some sign of non-perpendicular linearity on scraper G417 in Plate 20A. Both assemblages show varied manifestations of polish on their bits, but the experimental scrapers exhibit a far greater amount of more highly developed depositional polish covering a larger and more invasive area of the bit. This statement assumes, of course, that the deposits observed on these scrapers, described as polish in this text, and documented in the accompanying images can indeed be termed polish. Whether or not polish proves to be the most correct term for the observed phenomena, it is readily apparent that in the case of the experimental scrapers they are the result of use. The Gault scrapers present a more complex problem due to post-depositional factors. Soil polish and the various products of chemical weathering such as stains and patinas, as well as calcium carbonate encrustations can all mask or modify polishes. However, when deciding whether or not the various manifestations of these polishes are the result of use, location becomes extremely important. For example, scraper G364 exhibits the glassy lacquer polish over nearly the entire tool surface, but higher development on the bit, spurs, and lateral edges illustrated by opaque forms seems to indicate use.

Taken together, these data provide evidence regarding the function of the Gault scraper bits. It is a given that the use-wear characteristics found on the experimental scraper bits describe tools whose function was hide work. Regarding the experimental scrapers, the minimal amount of flaking along with the pervasive and intensive edge rounding indicates a soft material. Linear features, oriented perpendicular to the edge, imply a transverse, or scraping, motion. Thick, dense, well-developed polish covering an extensive surface area indicates, a non-rigid worked material, the presence of a liquid medium, a heavy load on the tool, a relatively long interval of work (an interval of work can alternatively be thought of as a number of strokes), and a moderate to low edge angle.

On the other hand, the intensive flaking and edge damage prevalent on the Gault scraper bits, especially in the center, suggests that these tools were likely used on a more rigid material than hide. Asymmetric and non-curving bit shapes like G248A and G172 also preclude hide scraping as a function. The diminished amount and development of polish as well as edge rounding also suggest scraping a drier, more rigid material. The steep edge angles also indicate use on a non-flexible material, as well as indicating the last episode of resharpening in the haft (Wilmsen 1968:986). Comparison of the use-wear characteristics on the experimental bits to those on the archaeological bits strongly suggests that the Gault scrapers were not used as hide scrapers subsequent to their last resharpening episode.

Spurs. As reported above, there is little doubt that the spurs, however created, were utilized. As documented by the images, spurs display flaked and broken tips indicated by feathered and step scars as well as scars from bending or snap fractures. Furthermore, the flake scar ridges as well as the edges of the spur tips are heavily rounded, in some cases to the point of effacing the flake scars. Linear indicators are present, not only on the dorsal or ventral aspects of the spur, but in some instances they are present on flat snap-fracture scars that sometimes form the face of the spur tip. Their directional orientation in relation to the spur edge varies from parallel to perpendicular, and oblique indicators may trend toward either end of the tool. The amount and development of polish varies considerably, but not to the extent of that found on the bits.

In some instances, the entire spur is enveloped in clear glassy polish, while in others the polish is limited to an opaque band on the edge. The opaque polish is also very glassy and may be thick enough to mask the texture of the rock surface below it, or the rock texture may be distinct despite the presence of the opaque polish. Random streaks as in Plate 20E-G and streaks ending at step fractures as in Plate 11E were not found. The thick non-glassy opaque deposit found on remnant flakes on the bits as in Plate 11A-D is likewise not found on the spurs.

These characteristics not only affirm the probability that the spurs were used, but can also afford indications as to how they were used. The snap fractures and step fractures indicate some amount of force and a fairly rigid worked material. Since the thickness of the spurs averages only about 1.6 mm, this kind of force could be generated whether or not the tool was hafted at the time the spurs were being used. The heavy rounding suggests a repeated motion for a fairly extended duration, while the size and shape of the spurs suggest an activity requiring some precision and by extension, a precision grip. Linear indicators further attest to such an activity. Polish variation is more problematical. In some cases, the polish covers nearly all the spur and varies in density; in other cases, it is restricted to a band near the edge. This could indicate use on different materials or a difference in one or more of the other factors that affect polish development. More specifically, it could be the result of a difference in the rigidity between worked materials or the depth that the spur has cut into a rigid worked material. Given the above evidence, it seems safe to suggest a scoring or grooving activity in a rigid material such as wood, bone, horn, or antler.

Lateral Edges. Hafting endscrapers with rawhide lacing is easily done and results in a very effective joint. When using this method, it has been my observation that the lateral edges of the stone should extend past that portion of the haft on which the scraper rests in order for the stone edges to directly contact the rawhide lacing. The irregular contour of the lateral edges provides a means by which the lacing can be tightened without slipping. The small projections on the stone edge bite into the rawhide, especially if the lacing is applied wet. As the rawhide dries, it shrinks, which further aids in providing a strong, tight joint. Hafting of this nature produces little haft wear when scraping hides because the tightness with which the scraper is bound allows very little movement. The only evidence of haft wear found on the experimental scrapers is a band of polish along the lateral edges and half-moon scars on feathered lateral edges. Examples are shown in Plates 3K, 5M and 6K. Because of their size, one might need to resort to a different but similar material in order to haft the Gault scrapers by the method just described. Sinew has the same toughness and shrinkage properties as rawhide, but produces finer lacing, thus reducing the bulk of the hafting material while retaining the proper strength. Sinew would have to be used in conjunction with glue to hold it in place.

Lateral edge wear on the Gault scrapers is more complex than that found on the experimental scrapers. The lateral edges of some of the Gault scrapers present an interesting array of edge wear characteristics that are likely the result of more than haft wear. For example, there are the notches described above that occur at the junction of the bit and the lateral edge on seven of the nine spurred scrapers. These may have been created as an aid to hafting (Shott 1995:58-59). Further notching on lateral edges may have been in preparation for use. Similar Paleo-indian endscrapers from the Horner site show lateral edges deliberately prepared for use (Frison 1987:245-246). Notching and co-occurring edge scarring, rounding, linear indicators, and polish, suggest that these lateral edges may have become expedient tools after the scrapers were removed from the haft for discard. The lateral edges could have been used in conjunction with the spurs to shape rigid material such as wood, bone, horn, or antler. The two scrapers comprising Group C, G172 and G288EEE, most likely functioned from the beginning of their use-life as non-hafted, multi-purpose cutting/scraping tools given their morphology and use-wear characteristics.

Were the Gault scrapers used as hide scrapers? Given the data presented by such a small population, one can only say that they may have functioned as such at some point in their use-life. However, it is evident according to the visible traces, that just prior to entering the archaeological record, these scrapers were used on something more rigid than hide. If they had been used on hides, subsequent use removed those traces. In addition, the data show that at least some of them had three areas of use, not only the bits and spurs, but the lateral edges as well. It is noteworthy that no scrapers were recovered having a suite of use-wear characteristics matching either set of experimental hide scrapers. No scrapers were recovered that were not worn past the point of serviceable hide work. This indicates, with the exception of the two scrapers in Group C, that the Gault scrapers entered the archaeological record as discarded tools, being brought to the site for the purpose of replacement. In other words, the Gault scrapers were highly utilized and curated tools that would have received much of their formal scraping use away from the Gault site. Spurs and lateral edges, on the other hand, were used upon discard at the site, where they perhaps aided in shaping new hafts for new tools.

CHAPTER VII

CONCLUSIONS AND IMPLICATIONS

A fresh animal skin is a complex organ and its transformation into a useful leather product can be an enigmatic process, relying as it does on the activity of mechanical, biological, and chemical systems to facilitate the change. The process grows still more complex considering that differences in species, environment, and culture also affect it, not to mention that the hide working processes that concern archaeologists occurred in prehistoric times. However, as this thesis has shown, these prehistoric processes are not entirely unknowable, provided one draws careful inferences from all the available lines of evidence. The discussion in the following sections refers back to the five specific statements of purpose set down in the first chapter.

The Model

The model in this thesis is an analog of prehistoric hide processing that brings together several lines of evidence in order to throw some light on aboriginal hide working. The model was constructed by first isolating the steps that *must* be included to complete the process regardless of circumstances. This was accomplished by a study of the physiology of animal skin and the changes it must undergo in order to facilitate the process. Second, the constraints imposed by prehistoric life and technology were considered through a survey of ethnographic and ethnohistoric accounts. Also taken into consideration were variables such as animal species and sex, season, geographic place, and tool type. Finally, the actualistic practice of processing hides by using the tool in question to work toward a functional, museum-quality end product insured a close analogy to the work of ancient peoples and guarded against the arbitrary nature of the use-wear studies cited herein. The model is graphically illustrated by the flow diagram in Figure 6. Concerning the tool in question, this thesis supports the findings of Schultz (1989, 1992) that the hafted elbow-shaped endscraper is an effective hide-working tool, able to perform not only fleshing and dehairing, but thinning and breaking tasks with an efficiency comparable to modern steel analogs.

Clarification of the Process

Application of the model will help to standardize hide-working and use-wear experiments dealing with cultures across space and time by helping to separate those activities that are a function of the physiology of the hide and those that may be a function of environment or culture. With this knowledge the archaeologist is better equipped to determine whether hide work is likely to have occurred at a site and to discern the various possible hide-working activities when faced with a site where hide work is suspected to have occurred. Experimentation based on the model as well as consideration of the finished product can only improve on the arbitrary nature of previous hide-related studies cited and discussed in this work. Attention to the model and other information presented in Chapter II will help to standardize hide-working terminology so that words like *tanning* and *curing* are no longer so inclusive in meaning, but become specific to the activity for which they were derived. Standardization of experimental methods and terminology will foster less confusion and more accurate communication, as well as more accurate replication of the experiments of others.

That one is able to construct such a model clearly shows the value of actualistic studies and practical analogs. Starting with a definite goal for the used material based on ethnographic accounts and sound practice should have a positive affect on studies dealing with the other common contact materials usually dealt with in use-wear experiments, namely meat, bone, wood, grasses, antler, and horn.

Use-Wear Characteristics on the Experimental Scrapers Compared to Earlier Studies

Of the four attributes of use-wear described in the present study, namely edge flaking, rounding, striations, and polish, all were present to some degree on the experimental tools. Micro flaking was minimal as one might expect from working a relatively soft material such as hides. Most flake scars were of the feather or shallow step-terminated types. Flake scar arrises were mostly rounded, as were the immediate edge and other areas of high relief. Linear indicators were variable in that some were actual striae caused by small particles being dragged across the rock surface while others appeared to be streaks of polish or striae infilled by polish. Nonetheless, as indicators of direction, they were all transverse to the edge. This information is largely what has been predicted for non-rigid materials by earlier "low-power" studies of Odell and others (Odell 1979, 1981; Odell and Odell-Vereecken 1980; Tringham et al. 1974) discussed in this thesis.

Polish is the attribute whose characteristics most differ from earlier descriptions by Keeley and his followers (Newcomer and Keeley 1979; Keeley 1980; Vaughan 1985). The images presented herein show that polish is the attribute having the greatest variability. In fact, polish variability is what enabled the differentiation between fleshing and dehairing functions of the experimental scrapers, notwithstanding the small sample. Far from the one polish = one contact material paradigm of Keeley (1980) and Vaughan (1985), this study has shown that this variability can occur from working one contact material. This study further substantiates much of the important work carried out by Levi-Sala (1996) and Kay (1996, 1998) on the nature and development of polish. Many factors affect the development, and thus the appearance, of polish including raw material type, rigidity of the worked material, duration of use, load on the tool, the presence of a liquid medium, and the presence of abrasives. In addition, animal hide is a contact material whose physical properties change rather quickly once it is removed from the animal.

Every effort should be made to study the formation and development of polish on stone tools. Although they disagree on whether polish forms by deposition as well as abrasion or only abrasion, Levi-Sala's experiments reveal much about the mechanisms by which polish is formed, while Kay's images provide visual information about the nature of polish. Although the present study cannot completely resolve this issue, one can conclude from the information presented here that visually polish appears to have depth and substance that is not merely a question of cleaning. It must be kept in mind that some of the Gault scrapers were exposed to acid cleaning and still exhibited a thick polish that appears to be deposited. Several other conclusions regarding polish can be drawn from this study. Polish is sequential in development. Polish has the following attributes: location, amount and type of coverage, thickness, texture, brightness, color saturation, density, and transparency. Further, it possesses these attributes in varying degrees as depicted by the images presented here. However, not every step in the sequence between the beginnings of development and a highly developed polish will appear in all cases.

There is also the matter of the loosely bound substance that appears on the surface of both the experimental scrapers and the Gault scrapers. This study has shown that it is rather easily removed. Its presence on both modern and ancient tools, along with its easy removal, suggest that its presence has more to do with naturally occurring, ongoing processes in the rock than use, and yet its appearance is most prevalent in areas of apparent use.

Regarding microscopic imaging, the use of the microscope/camera set-up described here is clearly a great advance in microwear technology. The capability of capturing images of a three-dimensional sample that look three-dimensional and are also in color provides the analyst with visual information that is impossible to achieve with conventional imaging equipment.

From the review of use-wear literature and subsequent discussion, one can conclude that functional analyses must utilize all available lines of evidence in reconstructing prehistoric tool use. Product-oriented experiments, ethnographic analogy, site context, tool morphology, ergonomics, technological analysis, and functional analysis in the form of both “low-” and “high-power” microscopic analysis are all essential avenues for the investigation of stone tool function.

Are Different Steps in Hide Processing Reflected in the Resulting Use-Wear?

Regarding the central question of this thesis, the two groups of experimental scrapers could be separated based on fleshing and dehairing because the two groups are dependent on different factors of development. The question deals specifically with the tasks of fleshing and dehairing. Brink (1978), it will be remembered, considered this same question and concluded that the tasks were indistinguishable because he found the scraper to be ineffective at fleshing damp hide, but it de-haired damp hide easily although any wear was slow in appearing. However, because he found endscrapers ineffective at fleshing but effective at dehairing, he argues that any such wear patterns found on prehistoric tools must indicate dehairing (Brink 1978:112). His error lies in the assumption that hair removal is only accomplished by slipping, which leaves the grain intact. This is a practice that is not conducive to the brain tanning technique. In other words, Brink was not able to make distinctions in use-wear between hide-working tasks because he did not have an understanding of the process.

Some distinction between these two tasks is apparent based on the microscopic images of polish development generated during the present study. The fleshing scrapers exhibited a greater amount of the more highly developed depositional polish than did the dehairing scrapers. This is more than likely a function of the moisture content of the hide when fleshing commenced than any other variable affecting polish development described in this study. Admittedly, the sample was small and the same type of study covering a much larger sample of scrapers is needed. Such a study would necessarily encompass a considerable time span and would be quite expensive in terms of bison hides purchased at current prices.

Can These Use-Wear Features Be Recognized in the Archaeological Record?

This question was addressed by comparing the use-wear characteristics found on the experimental scrapers to those found on the endscrapers from Gault. In general, the suite of use-wear features on the experimental scrapers was absent on the Gault scraper bits. The intensive flaking and edge damage prevalent on the Gault scraper bits, especially in the center, suggests that these tools were likely used on a more rigid material than hide, as does the diminished amount and development of polish and edge rounding. This is further indicated by the steep edge angles (Wilmsen 1968:986), all of which strongly suggests that the Gault scrapers were not used as hide scrapers subsequent to their last resharpening episode. While it is certainly possible that a suite of hide working features could be recognized in the archaeological record, this was not the case at the Gault site.

Implications and Areas of Further Study

This thesis has generated some far-ranging implications and areas for further study. First, the imaging equipment described above and used in this study will lead to still better imaging and more accurate determinations of tool uses as we continue to explore its capabilities. It will generate further studies into the nature and development of polish, likely incorporating use of the SEM as well as research from other fields such as chemistry and materials science. We can formulate the following questions: If polish takes a truly depositional form, and this thesis certainly indicates that it does, then what is its composition? Does it contain organic material? How is it bound to the tool surface? Can it be extracted or collected? Can it be dated? What of the micro-cracks and crevices? If they trap organic matter, under what conditions will it survive years of deposition? Can it be extracted and dated? These are exciting question indeed. As the research moves forward and these questions are answered, the study of microscopic use-wear will gain momentum, becoming an important line of evidence in any functional study of stone or bone tools. Finally, this study should demonstrate the importance of constructing actualistic, task-based analogs when we design experiments to explore the function of ancient tools.

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APPENDIX

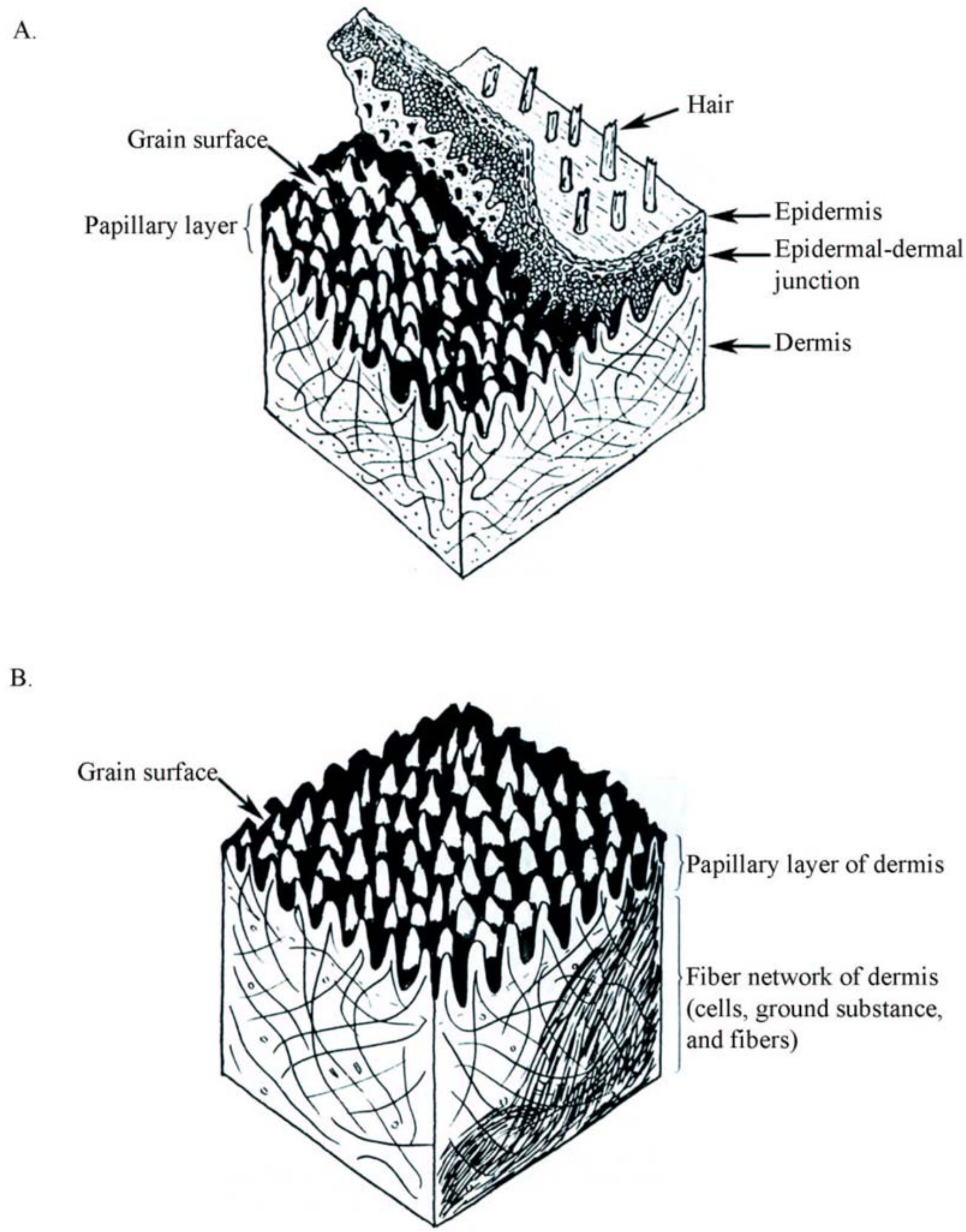


Figure 1. A) Diagram of a block of skin showing epidermis, epidermal-dermal junction, and dermis. A portion of epidermis is peeled off to show papillae in the grain surface (Reed 1972:17). B) Diagram of a block of dermis showing rough grain surface supported by the dermal fiber network (Reed 1972:18).

Figure 2. A) Toothed flesher made from a trade gun barrel. B) Toothed flesher made from a long bone. A and B are examples of the one-handed fleshers described by Schultz (1989:46- 54) and used in my own work. C) A dull drawknife used in the present work as a beamer, a tool class described by Schultz (1989:8, 23-24) as being used to dehair deerskins. They are also efficient fleshing tools when the pelt is wet.

Figure 3. Close-up view of the teeth cut into the distal end of the bone flesher in Figure 2.

Figure 4. Examples of the elbow-shaped scrapers described by Schultz (1989:49-52; 1992: 343) and used in the present experiments.

Figure 5. Photograph illustrating the form in which the hair and grain are removed from a bison hide. Material removed from the flesh side takes a similar form when the hide is dry.

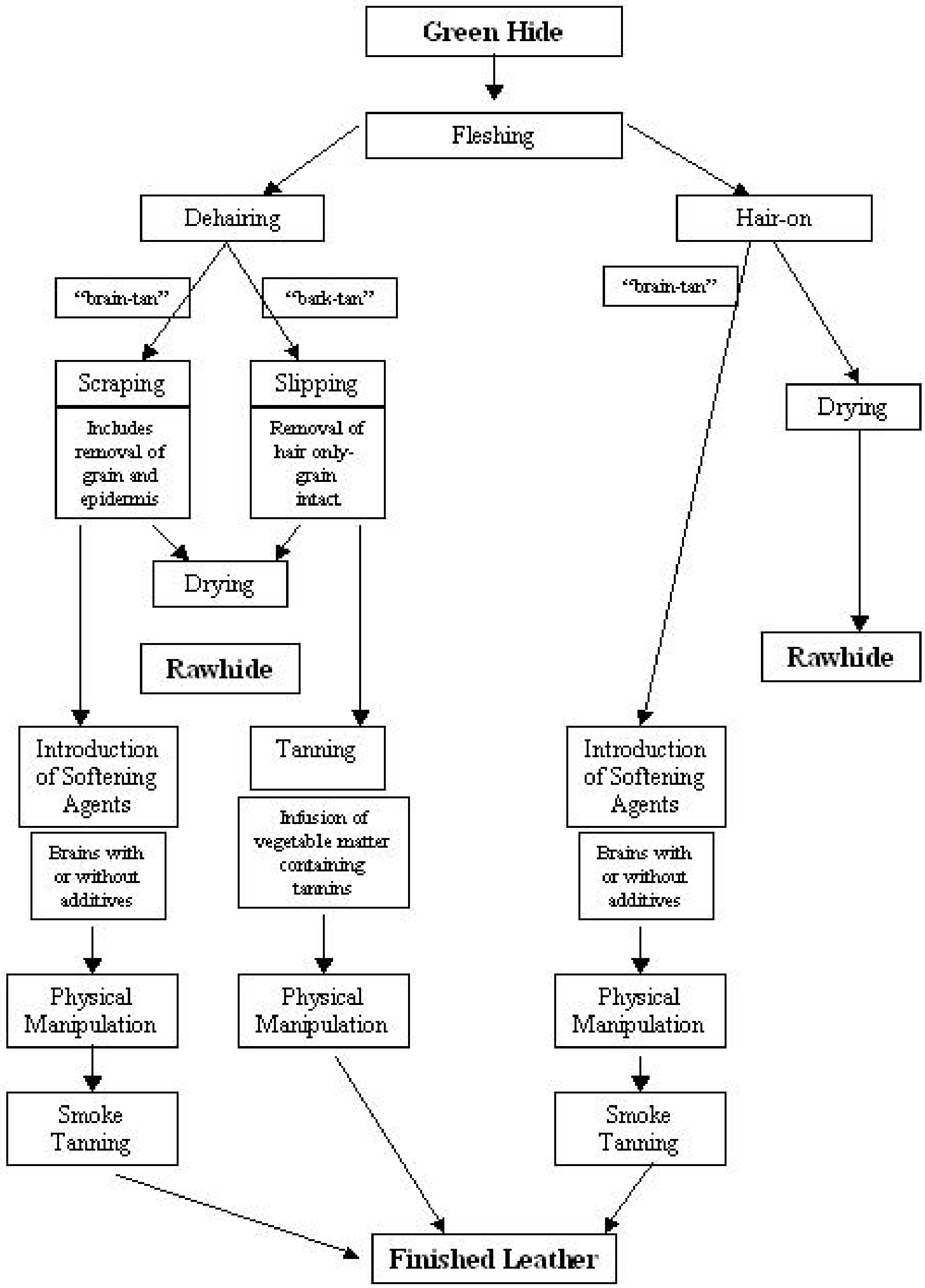


Figure 6. A practical model of hide processing by indigenous people applicable across space, time, and species.

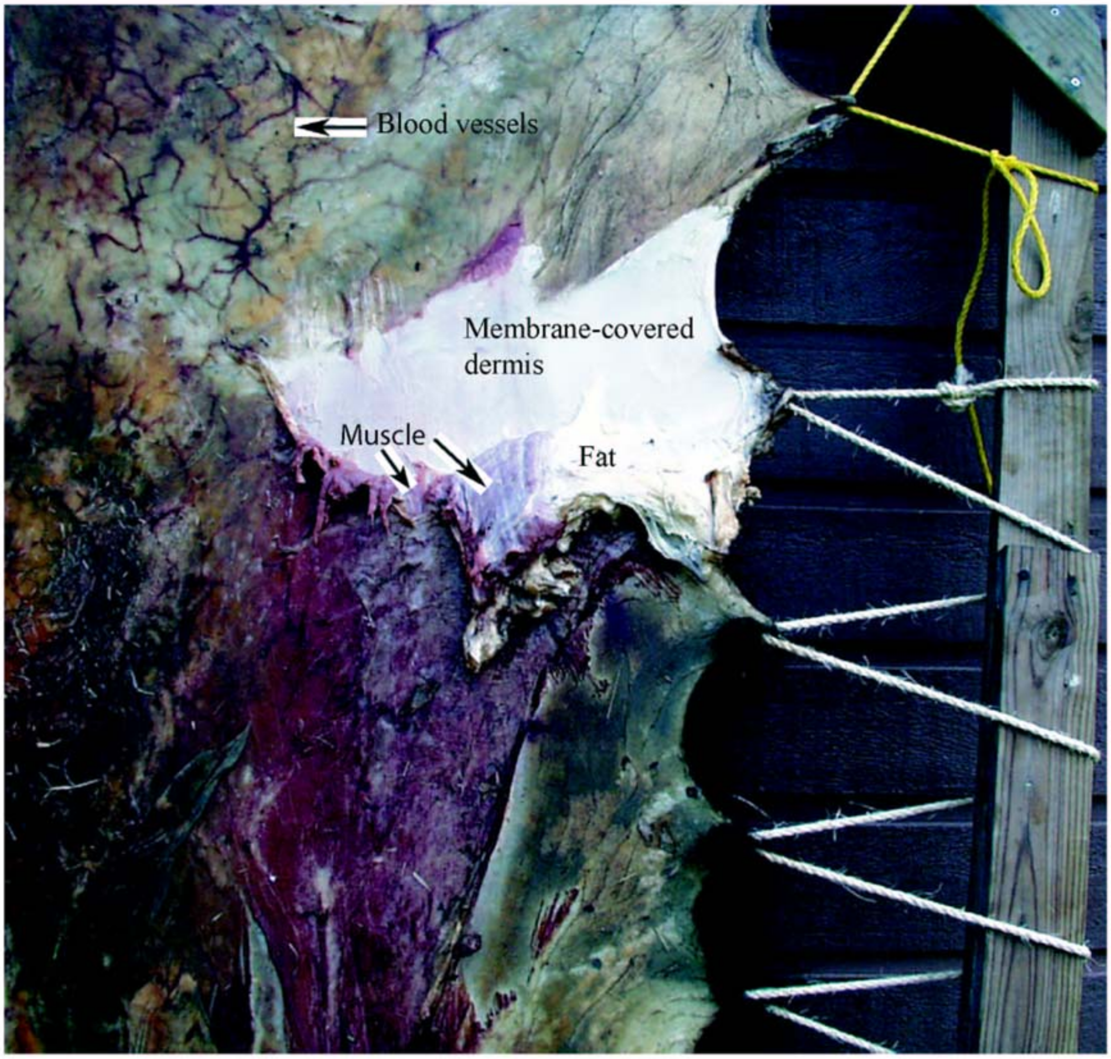


Figure 7. Photograph illustrating the initial stages of fleshing where large masses of tissue are being removed from a fresh bison hide. The white area is the dermis, which at this point, is still covered by a membrane that must also be removed in the later stages of the fleshing operation.

Figure 8. The winter hide from a two-year-old bull bison.

Figure 9. The latter stages of fleshing a nearly dried bison hide. Note the similarity between the strips of membrane in this image and those consisting of hair and grain in Figure 5.

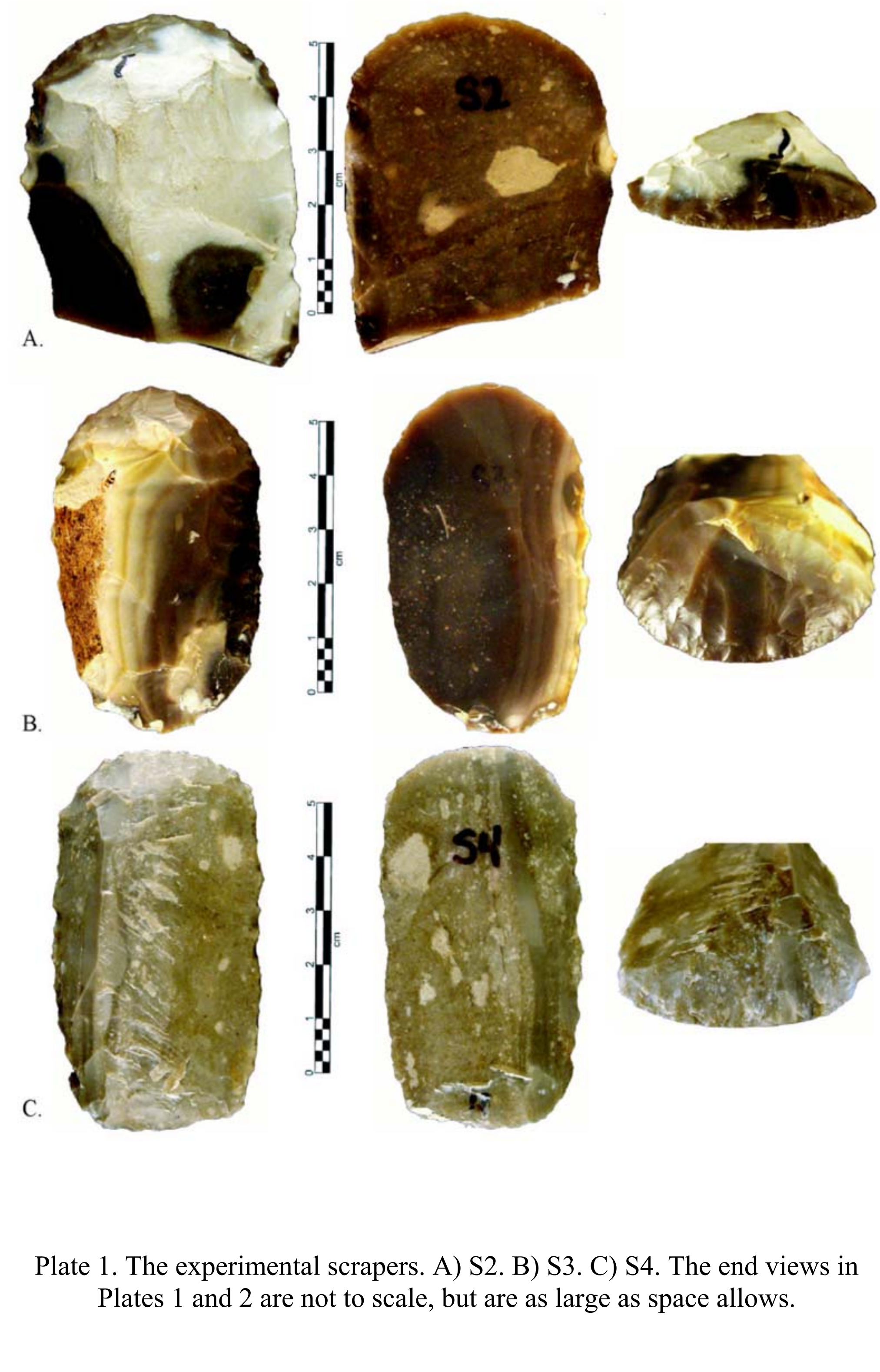


Plate 1. The experimental scrapers. A) S2. B) S3. C) S4. The end views in Plates 1 and 2 are not to scale, but are as large as space allows.

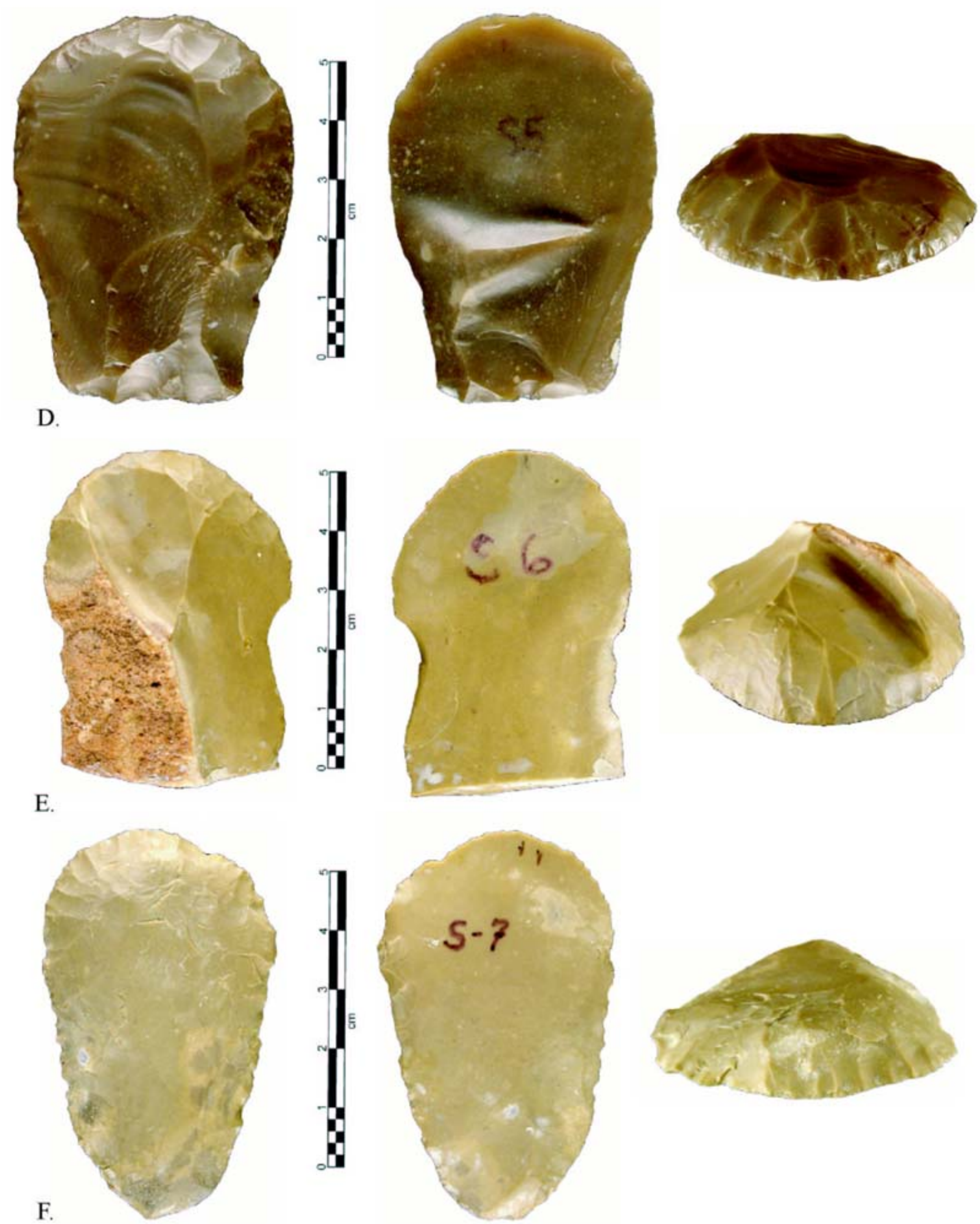


Plate 1, continued. D) S5. E) S6. F) S7.

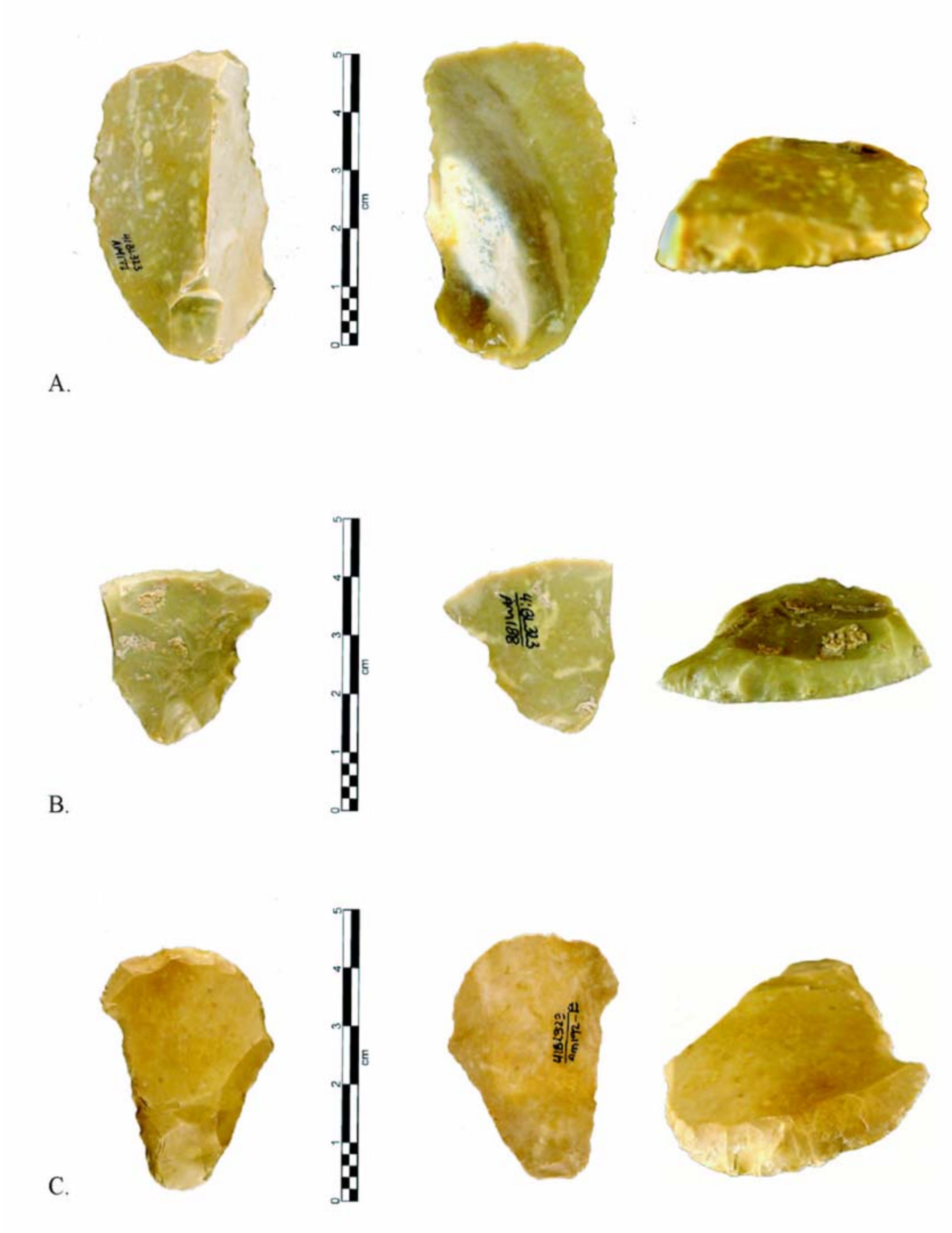
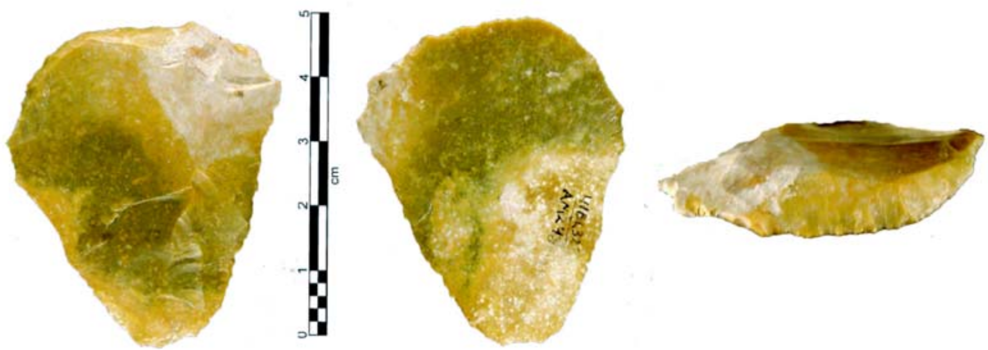


Plate 2. The Gault scrapers. A) G172 B) G188 C) G192B.

D.



E.

F.

Plate 2, continued. D) G227 E) G248 F) G288EEE.

G.

H.

I.

Plate 2, continued. G) G299 H) G301NNN I) G311.

J.

K.

L.

Plate 2, continued. J) G319 K) G364 L) G417.

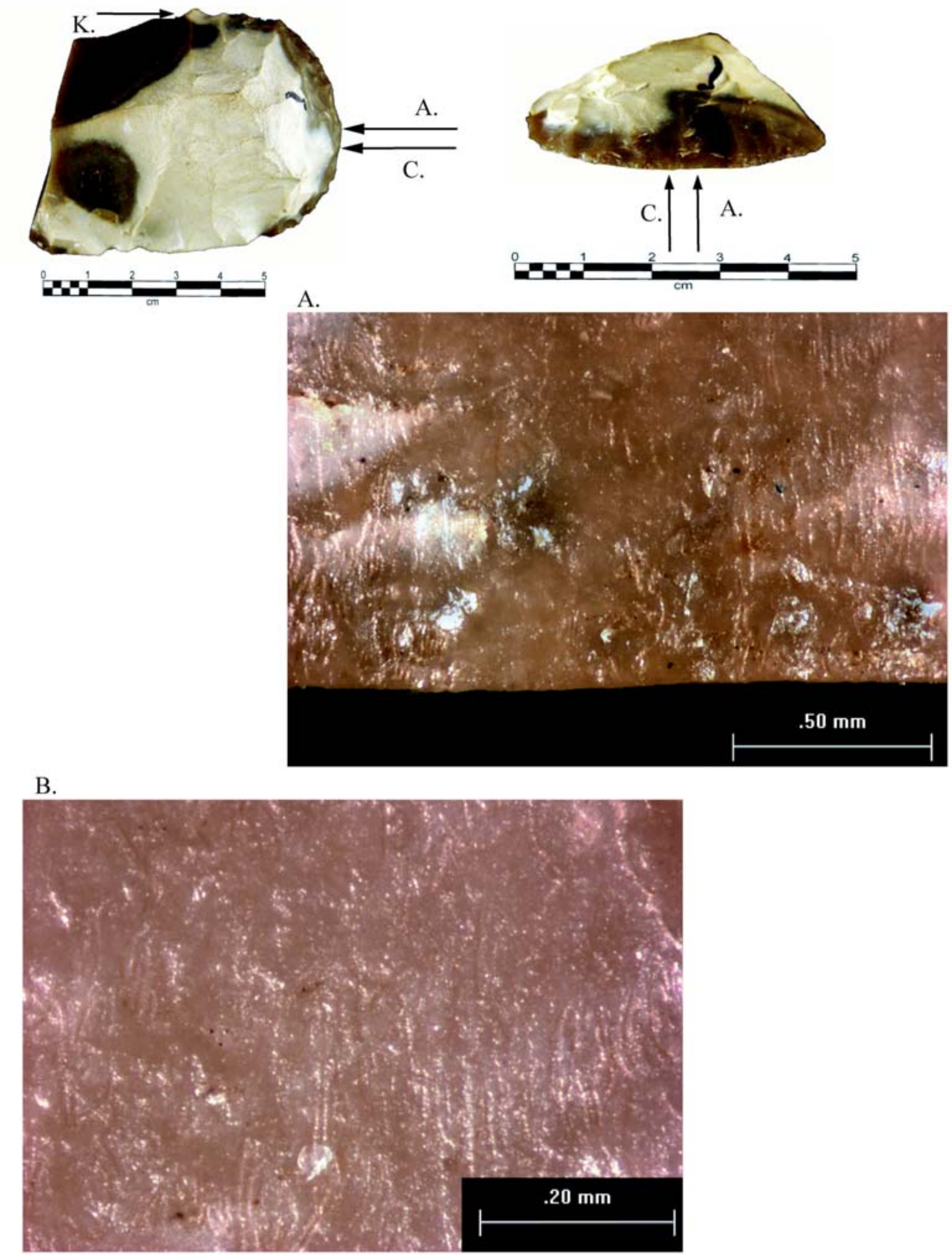
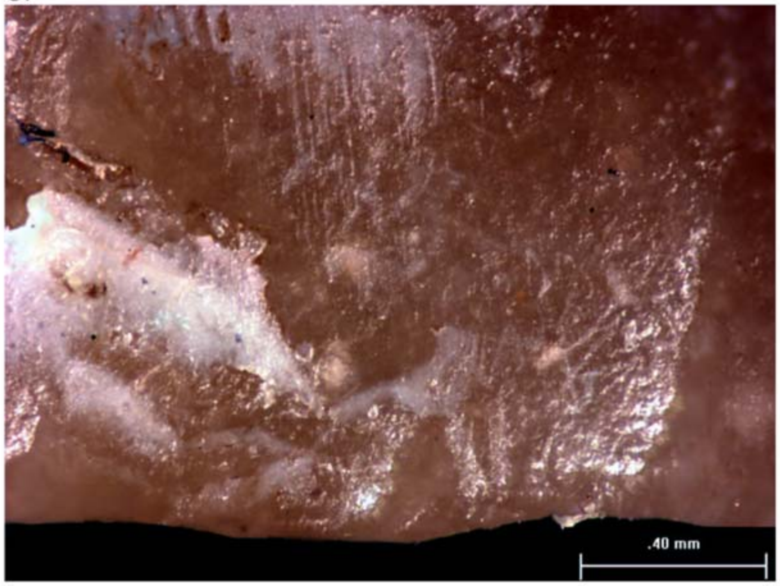


Plate 3. S2 use-wear images. Arrows indicate where the images were obtained.

A) Center of bit edge at 64x. B) Same area at 160x.

C.



D.

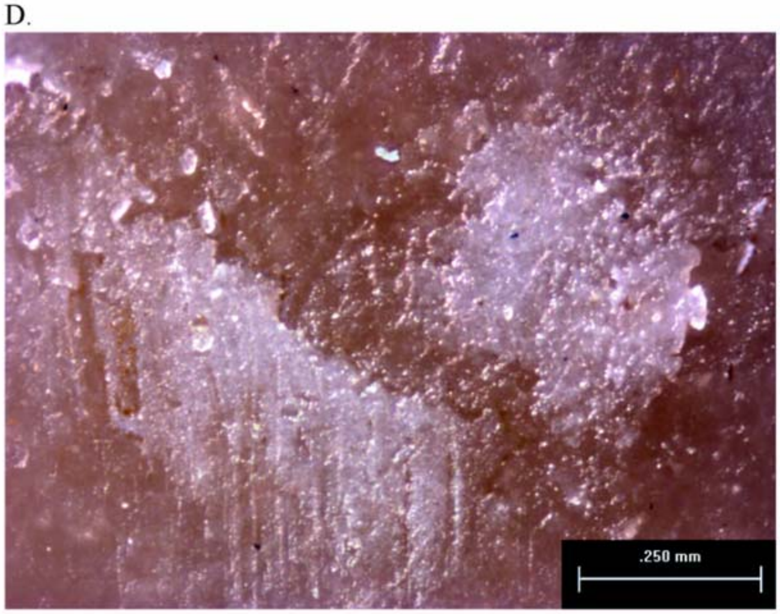
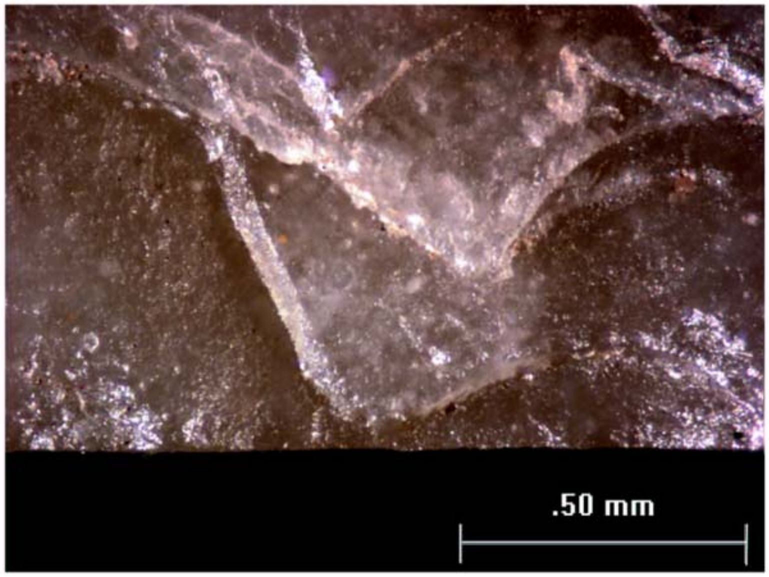


Plate 3, continued. S2 images continued. C) Same general area as A at 70x.

D) Upper section of C and just above at 100x.

E.



F.

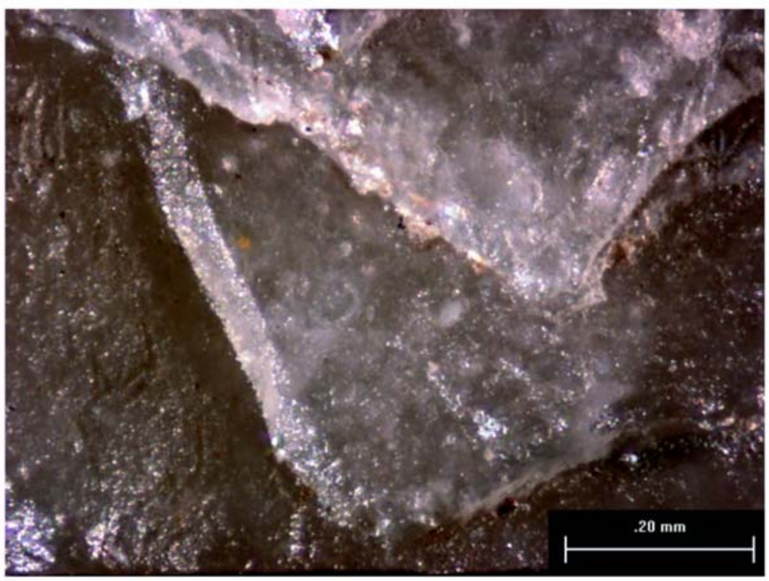
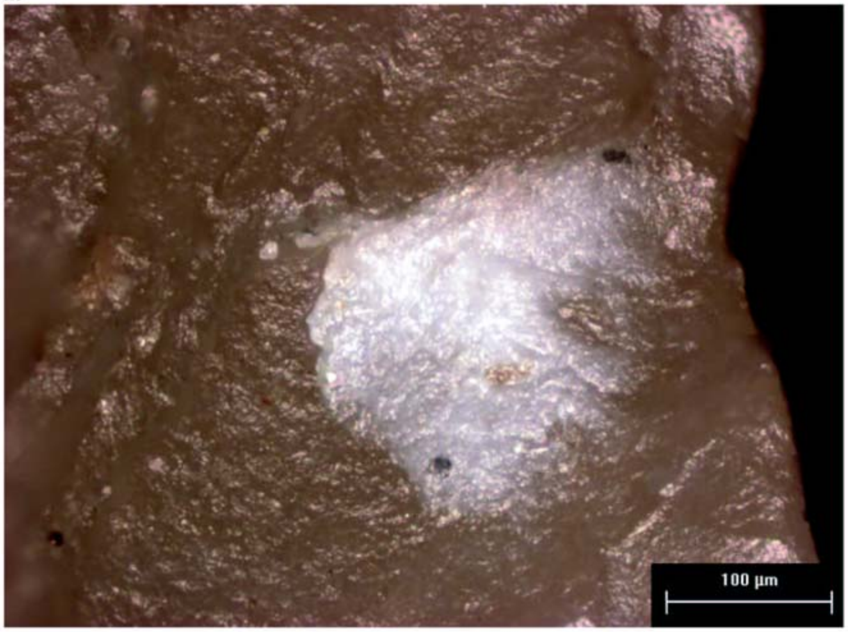


Plate 3, continued. E) Step fracture scar and remnant flakes at edge at 65x.

F) The same feature at 128x.

I.



J.

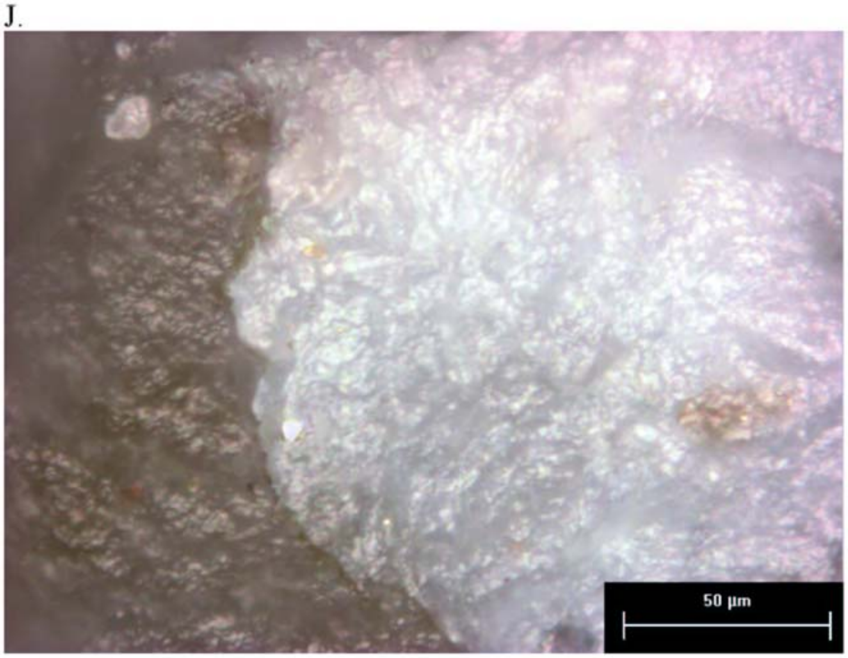
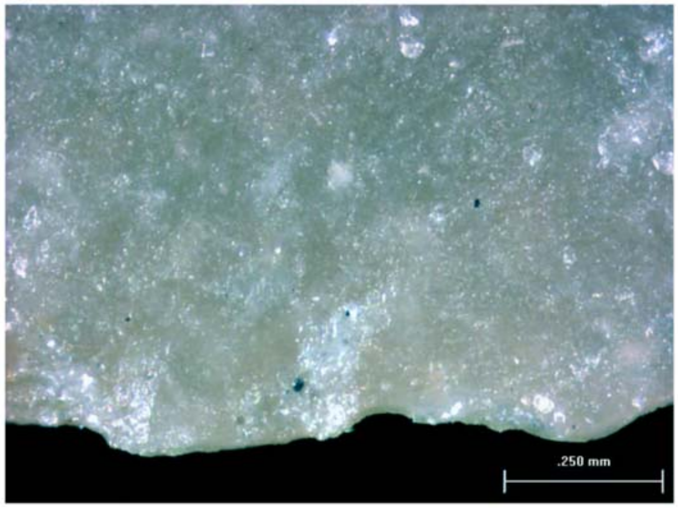


Plate 3, continued. I) Polish feature at tool edge at 200x. Tool edge is to the right in this image. J) Same feature and orientation as in I, showing polish boundary at 500x.

K.



L.

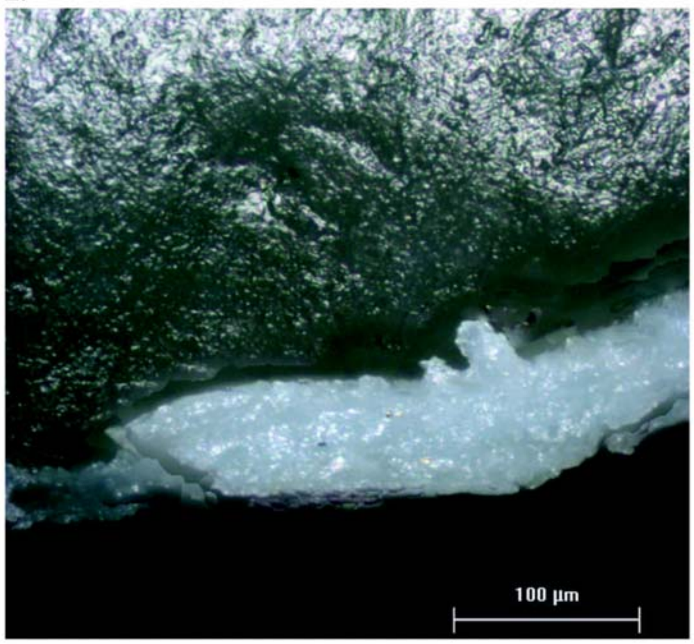


Plate 3, continued. K) Left lateral edge at 100x. L) Crystallization feature with small trailing edge filaments on the rounded dorsal surface of bit edge at 200x. The bit edge is pointed down.

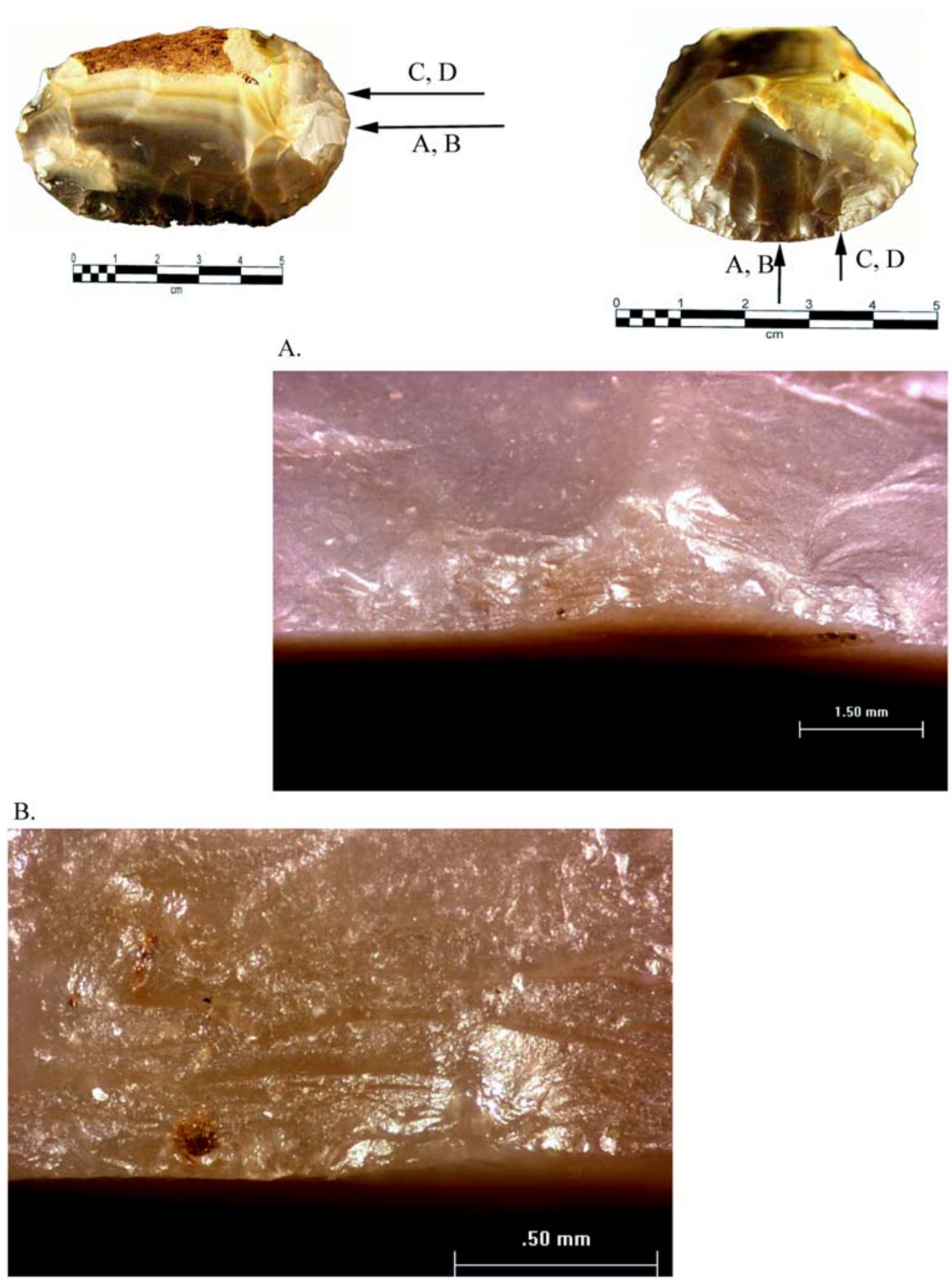


Plate 4. S3 use-wear images. A) Center of the bit at 12x.

B) The same general area at 64x.

C.

D.

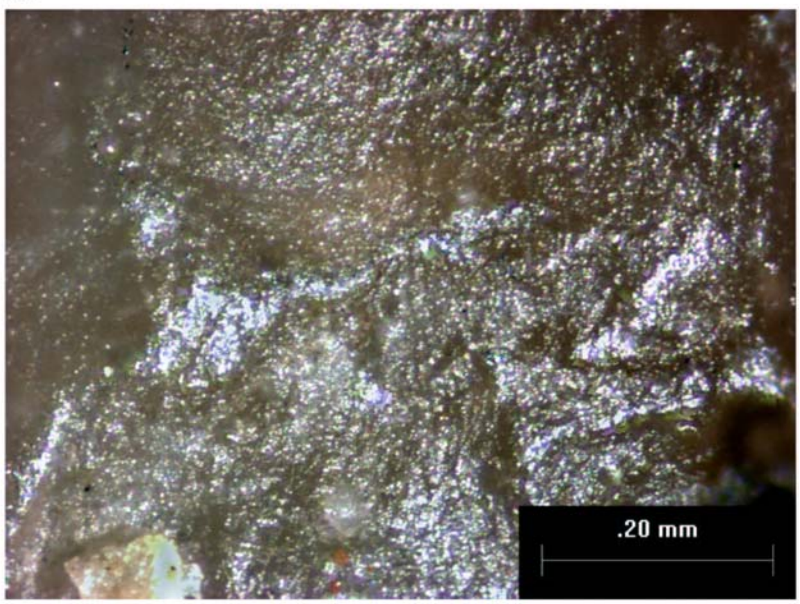


Plate 4, continued. C) The bit edge to the right of center at 140x.

D) Just above C at 160x.

E.

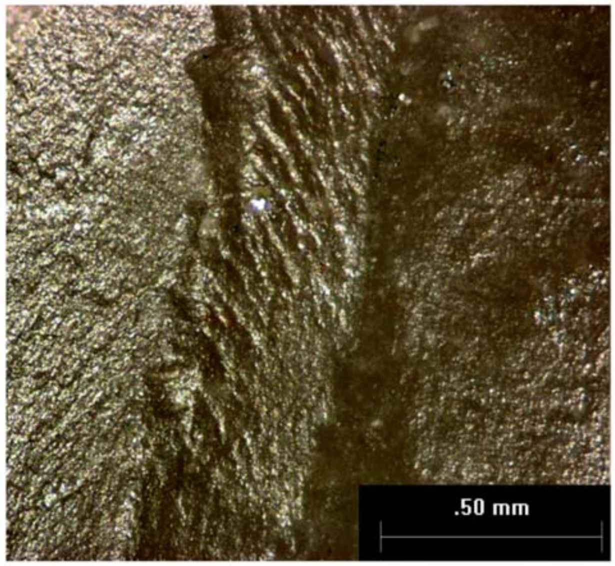


Plate 4, continued. E) Bit left of center just inland from the edge at 65x.

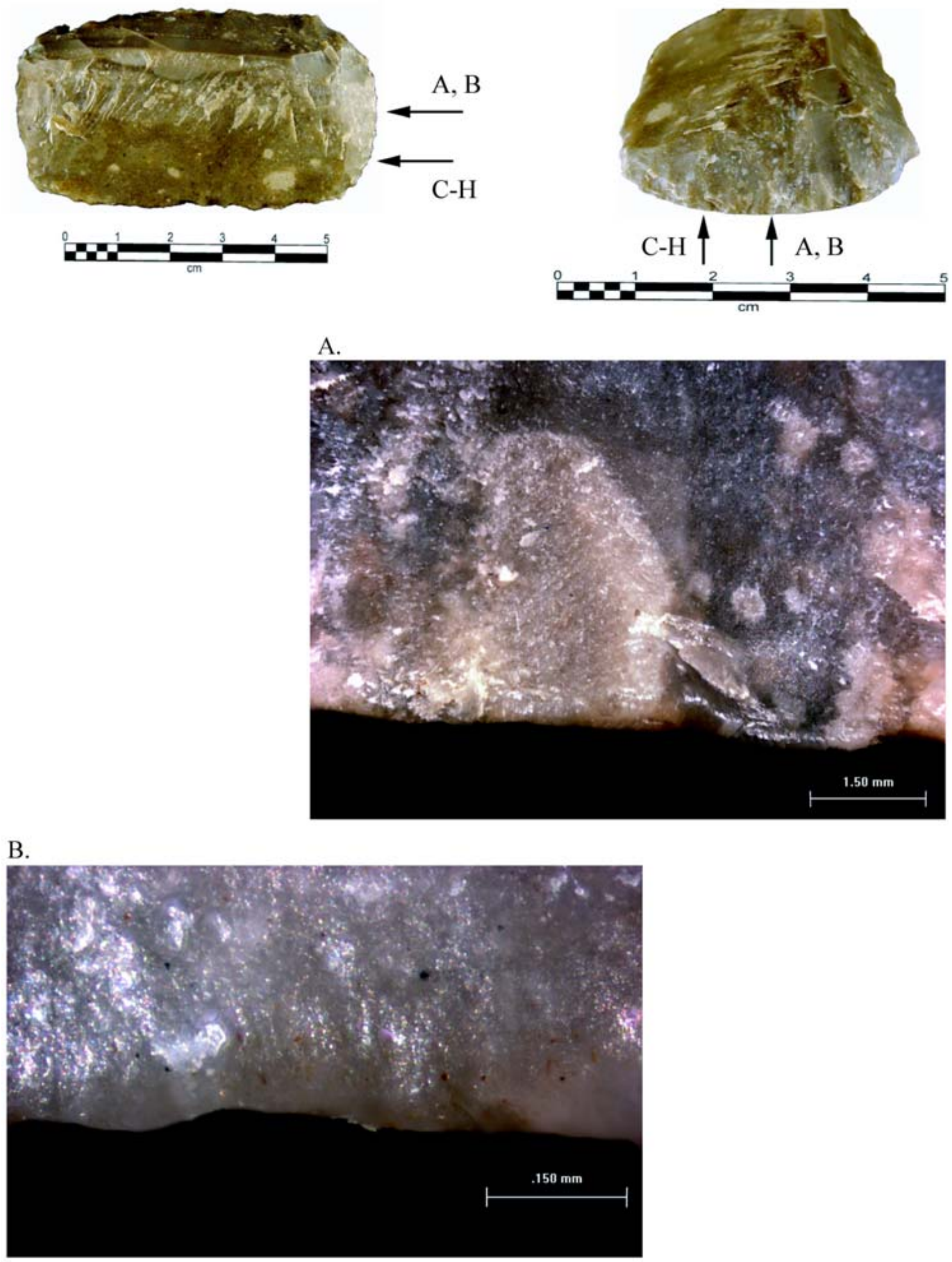
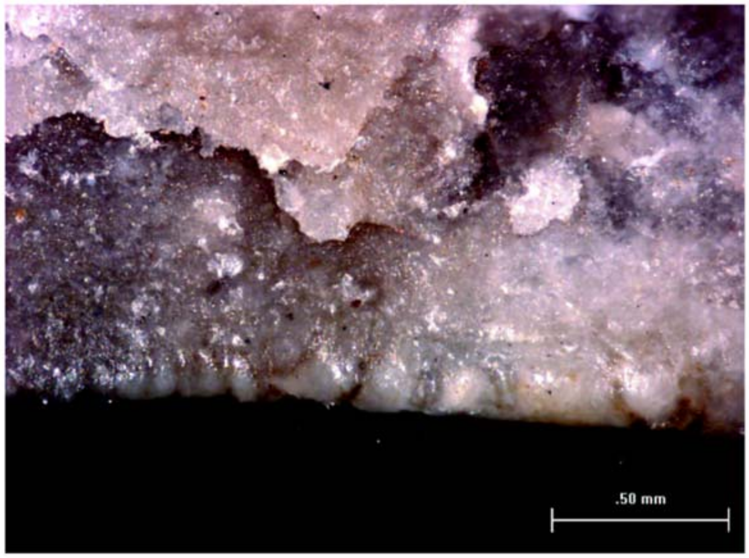


Plate 5. S4 use-wear images. A) Center of bit edge at 12x.

B) Center of bit edge at 160x.

C.



D.

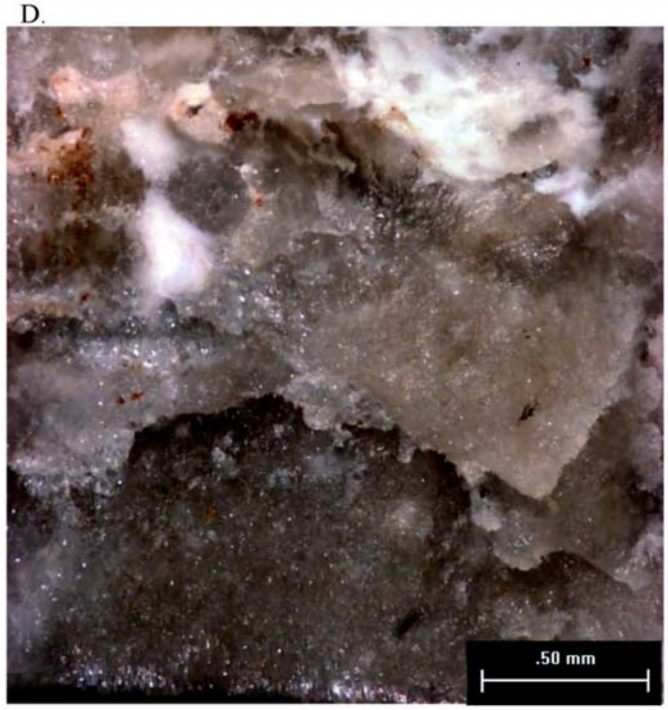
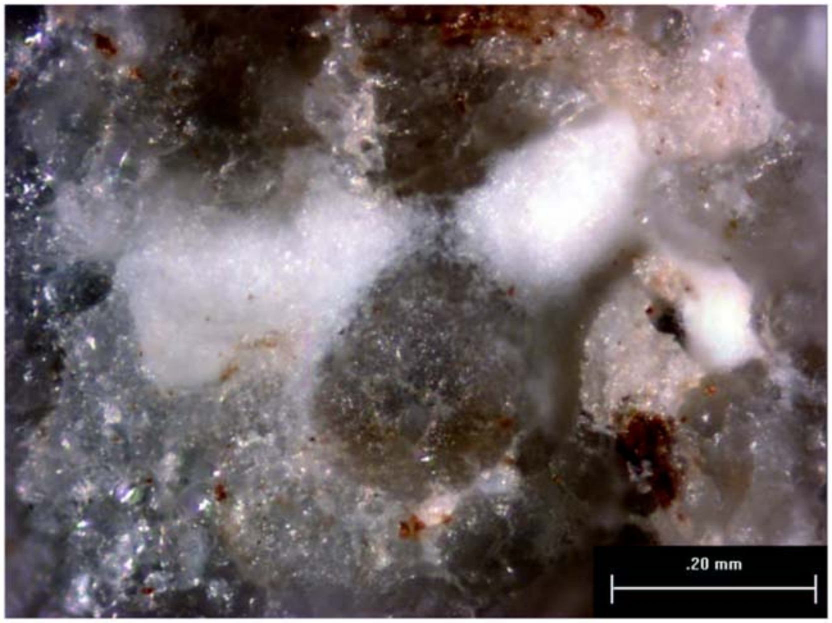


Plate 5, continued. C) Left of center bit edge at 50x. D) Narrower, deeper view of C, showing features inland from the edge at 40x.

E.



F.

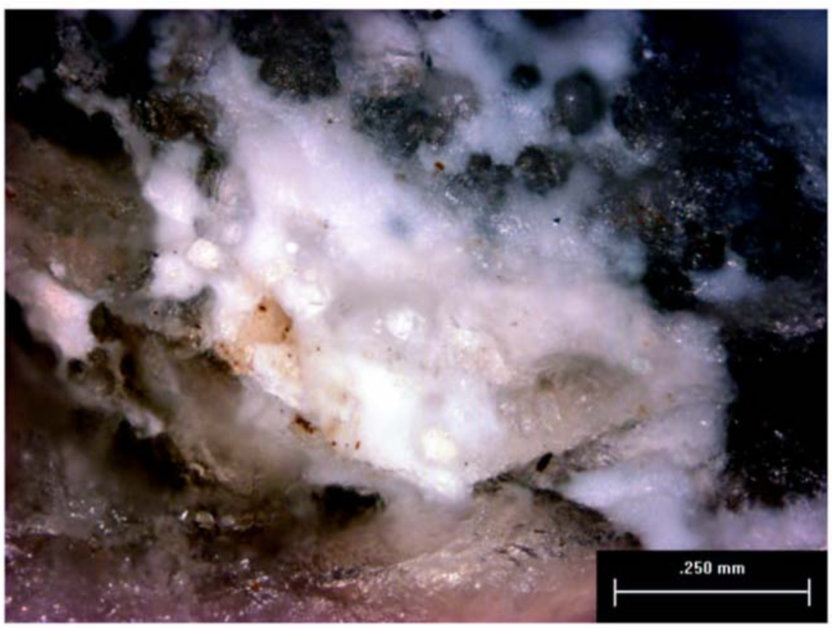


Plate 5, continued. E) The same area s D at 128x. F) Step fracture termination in the same general area just inland from the edge at 100x.

G.

H.

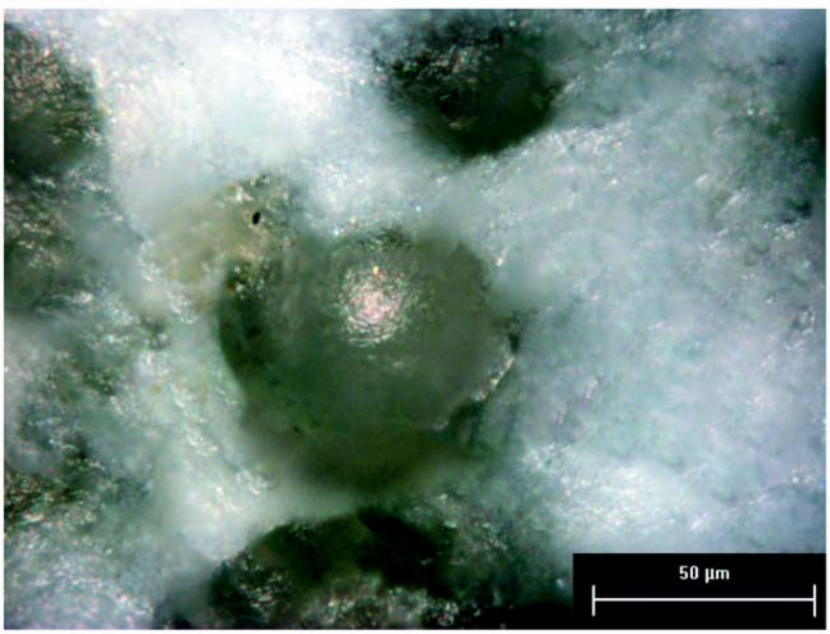
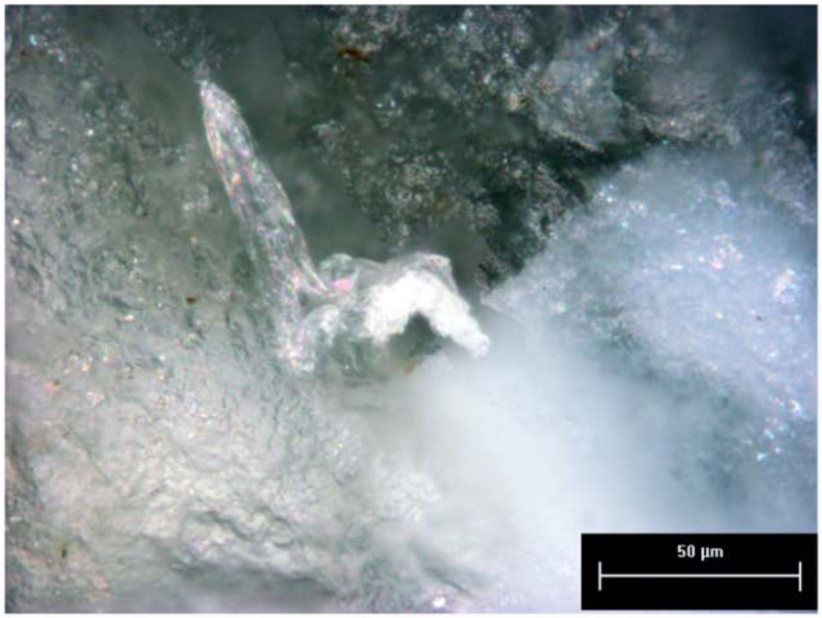


Plate 5, continued. G) Upper right-hand portion of F shown at 200x.
H) Lower portion of the same feature at 500x.

I.



J.

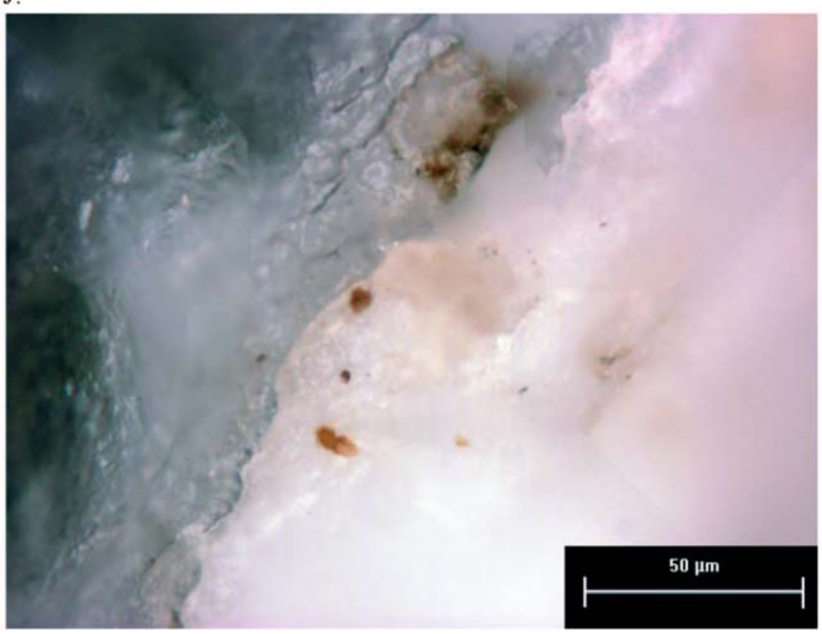
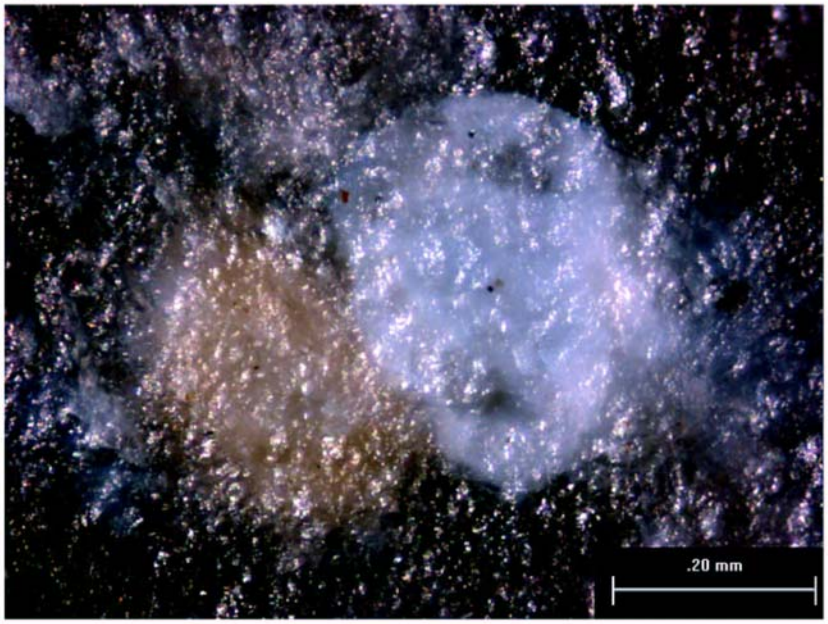


Plate 5, continued. I) Crystallization filament at trailing edge of polish at 500x. J) Polish boundary at 500X. Both of these images are associated with the features shown in C-H.

K.



L.

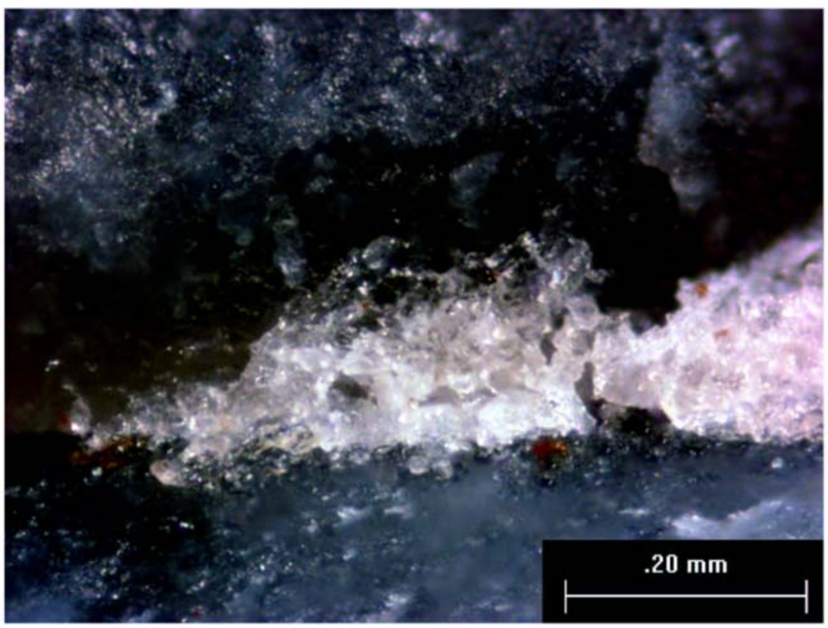


Plate 5, continued. K) Dorsal face of the bit, well inland from the edge at 120x. L) Face of a step fracture termination at the center of the bit edge at 160x.

M.

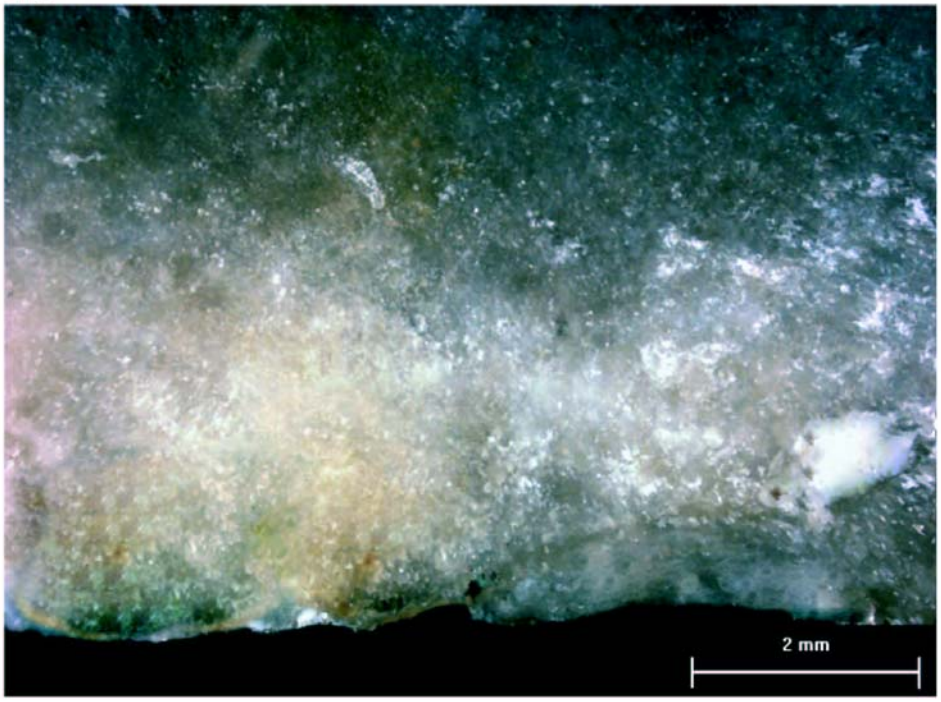
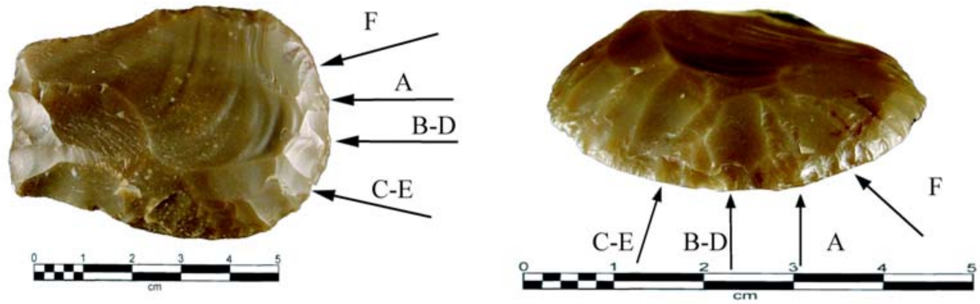
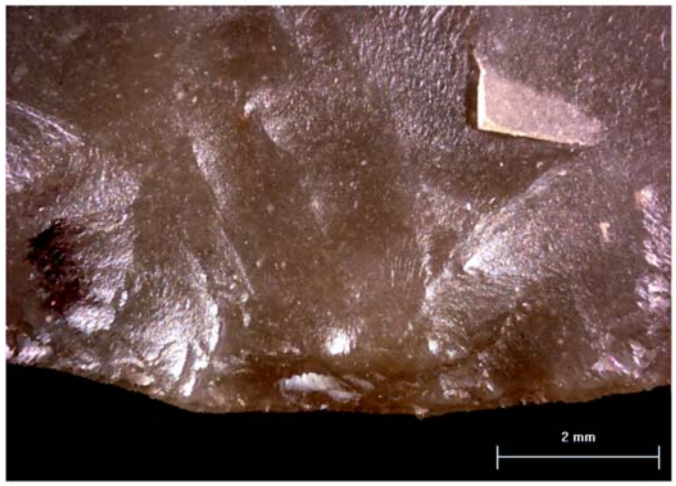


Plate 5, continued. M) Right lateral edge at 12x.



A.



B.

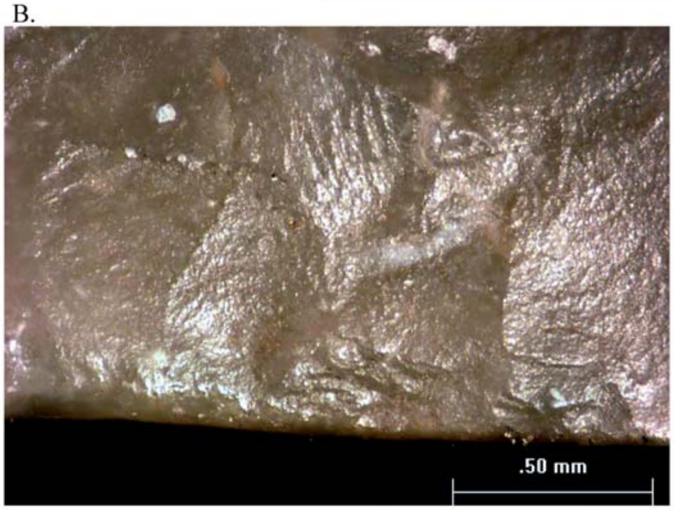


Plate 6. S5 use-wear images. A) Center of the bit at 12x. B) Center of the bit at 70x.

C.

D.

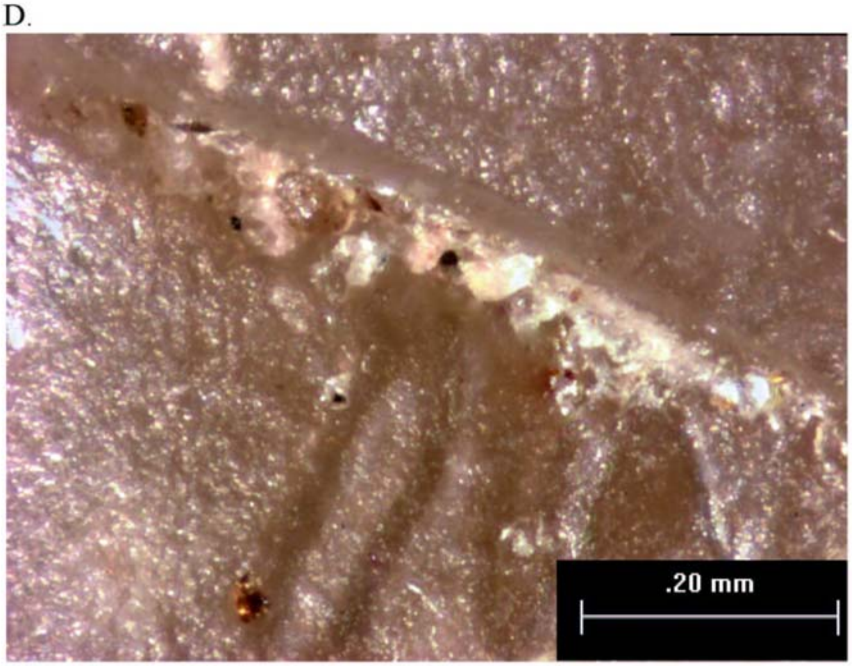
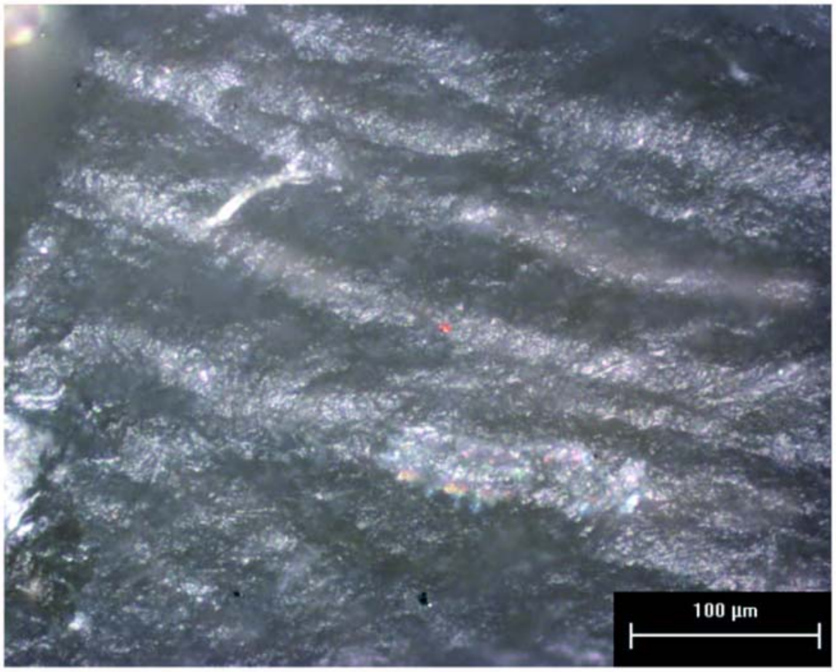


Plate 6, continued. C) Step fracture scar terminations inland from the center of the bit edge at 90x. D) Upper portion of C show at 160x.

E.



F.

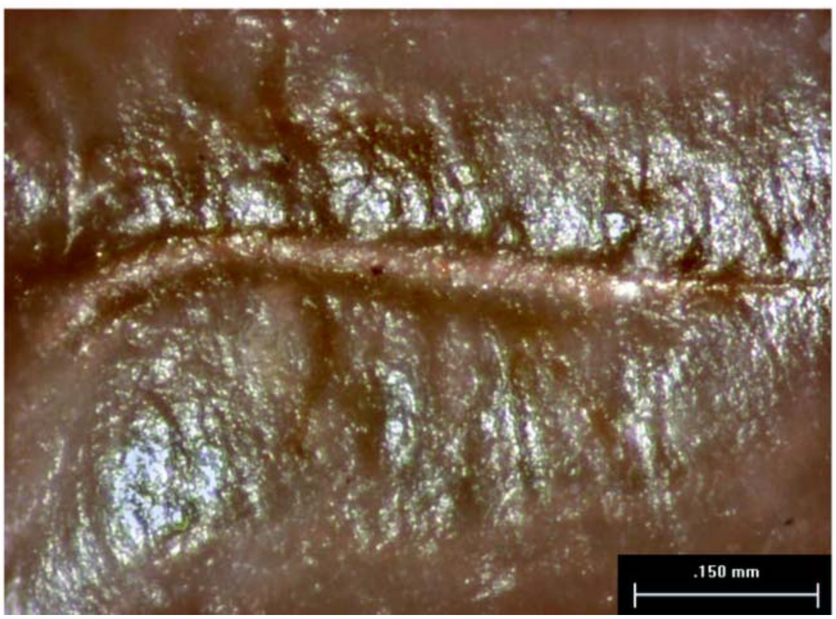
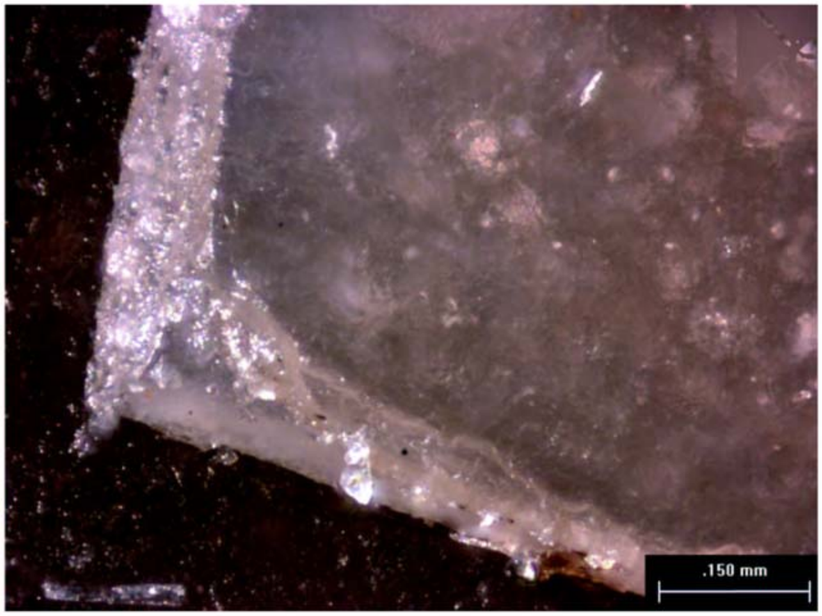


Plate 6, continued. E) Polished hacks at 200x nearly parallel to the tool edge.
F) Bit edge to the right of center at 160x.

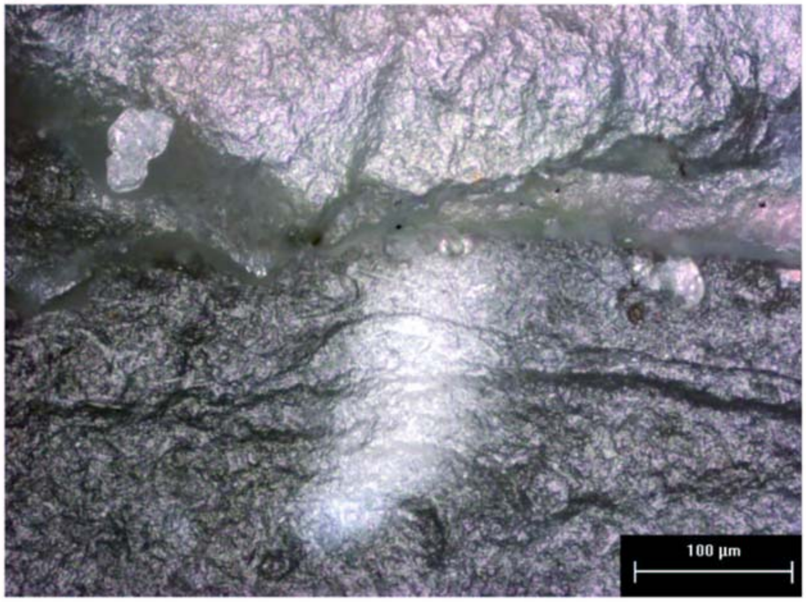
G.



H.

Plate 6, continued. G) Step fracture resulting in a remnant flake in the center area of the bit at 129x, H) Thin remnant flake with polish streak also near the center of the bit at 160x.

I.



J.

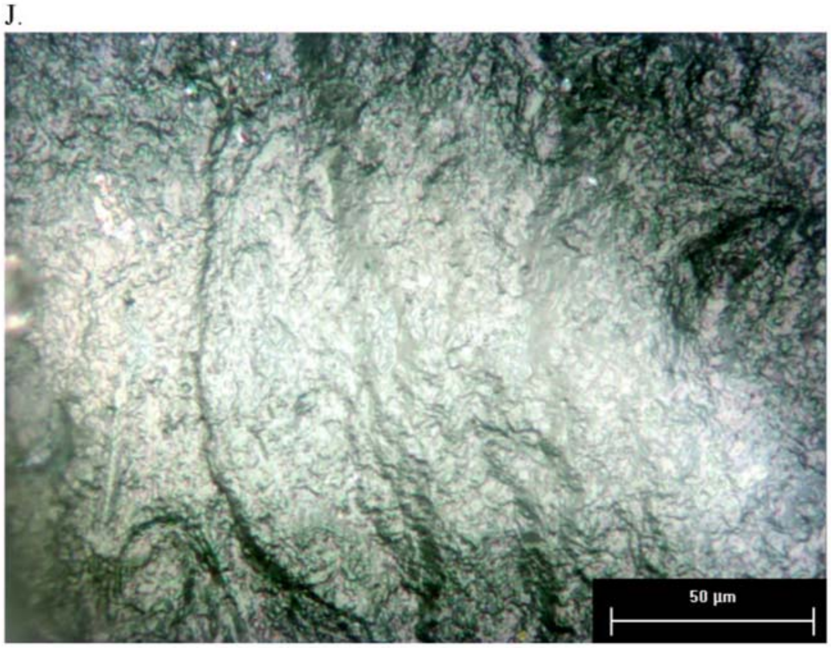


Plate 6, continued. I) Although similar in appearance to H, this image was taken from a slightly different locus at 400x, J) The same feature as in I, but here the edge is pointed to the right and shown at 500x.

K.

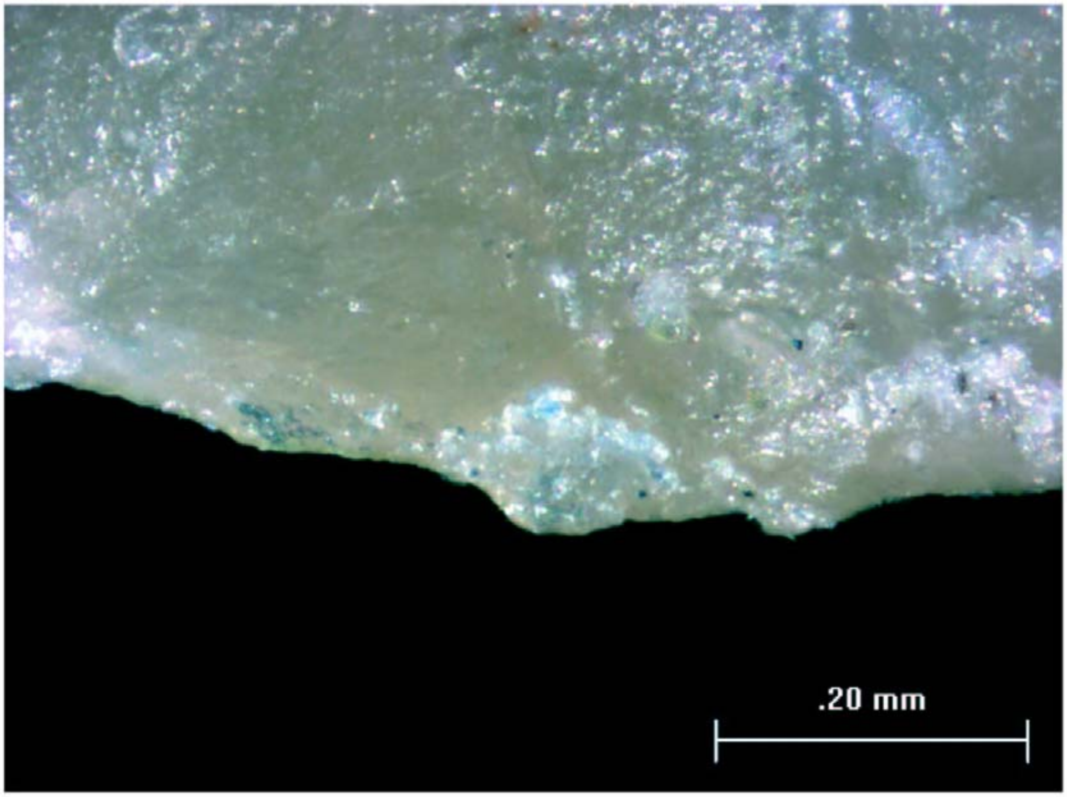


Plate 6, continued. K) Polish on left lateral edge at 160x.

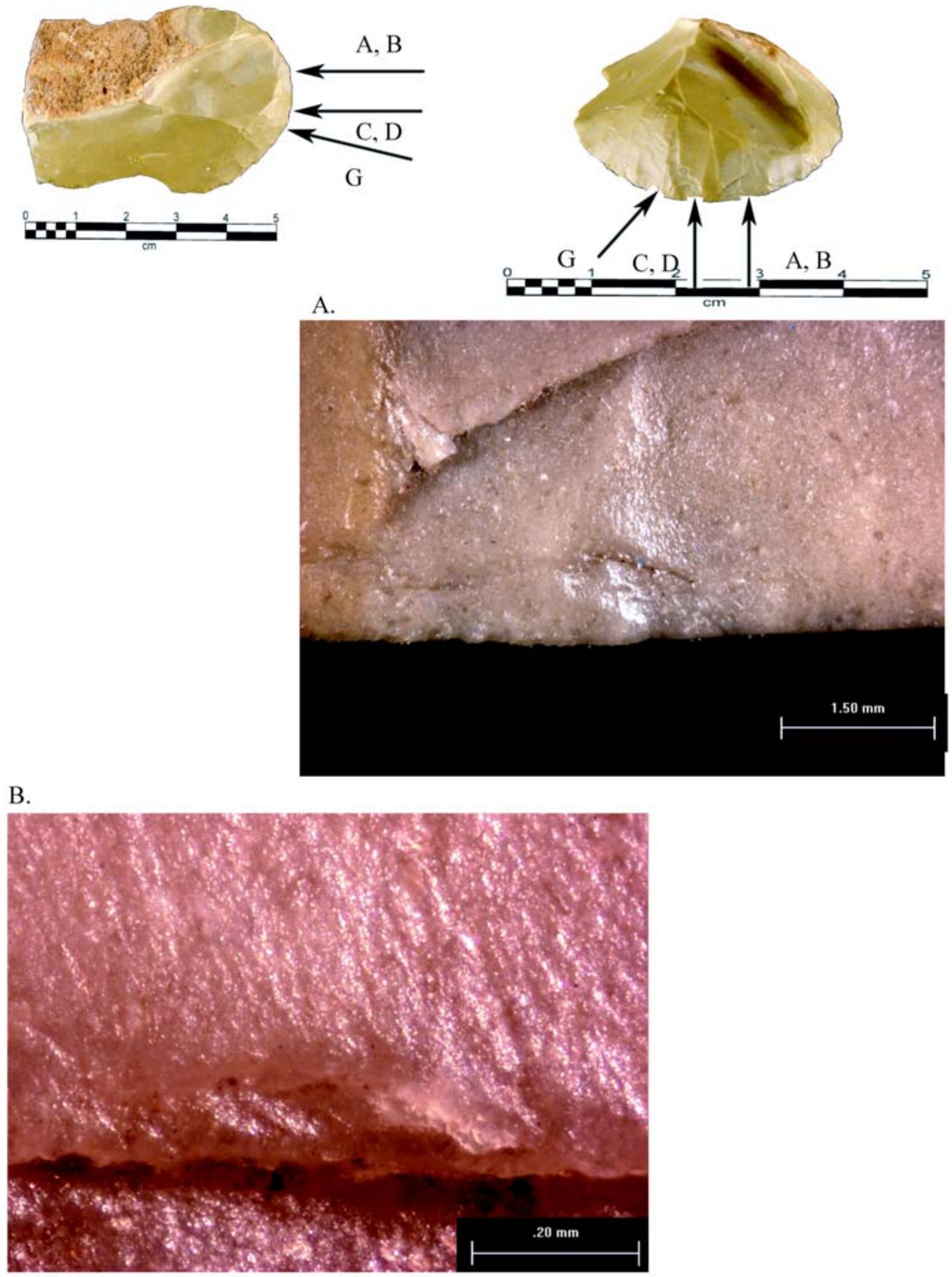


Plate 7. S6 use-wear images. A) Tight center of bit edge at 16x.
B) Center of A about one mm from the ege, taken at 128x.

C.

D.

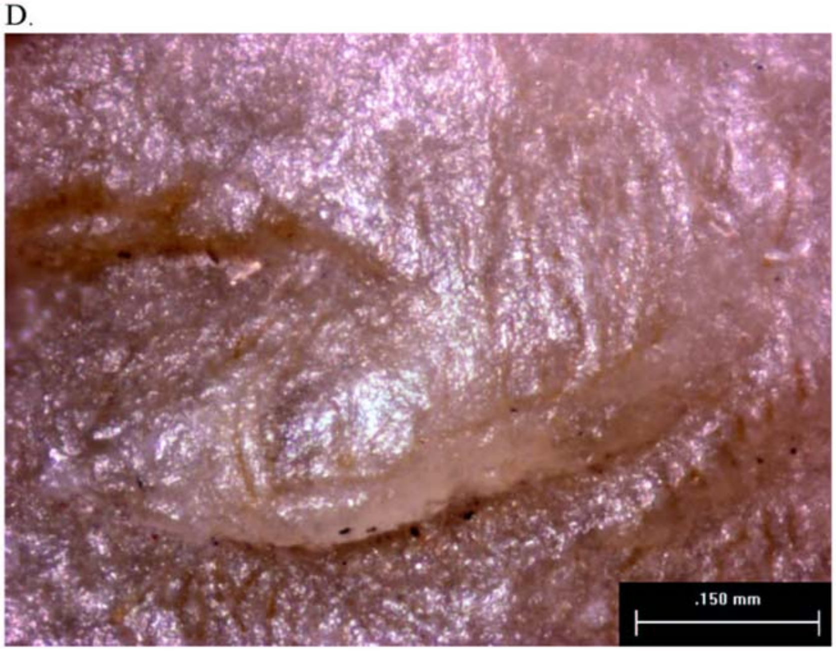


Plate 7, continued. C) Center of bit edge at 30x. D) Rounded feature to the left of the center of image C at 160x.

E.

F.

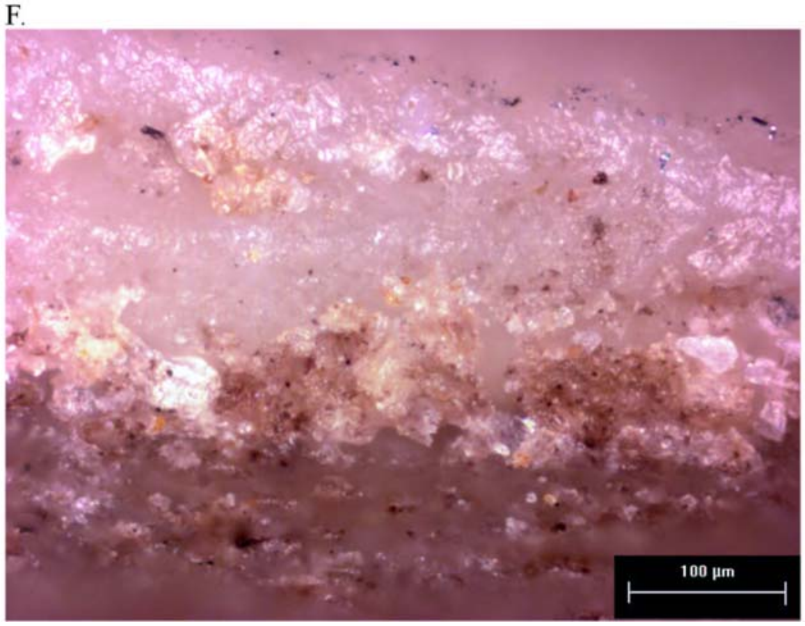


Plate 7, continued. E) Looking down on the face of the step fracture termination in the upper right-hand quadrant of image C at 160x. F) The same feature as in E at a slightly different angle and locus at 200x.

G.

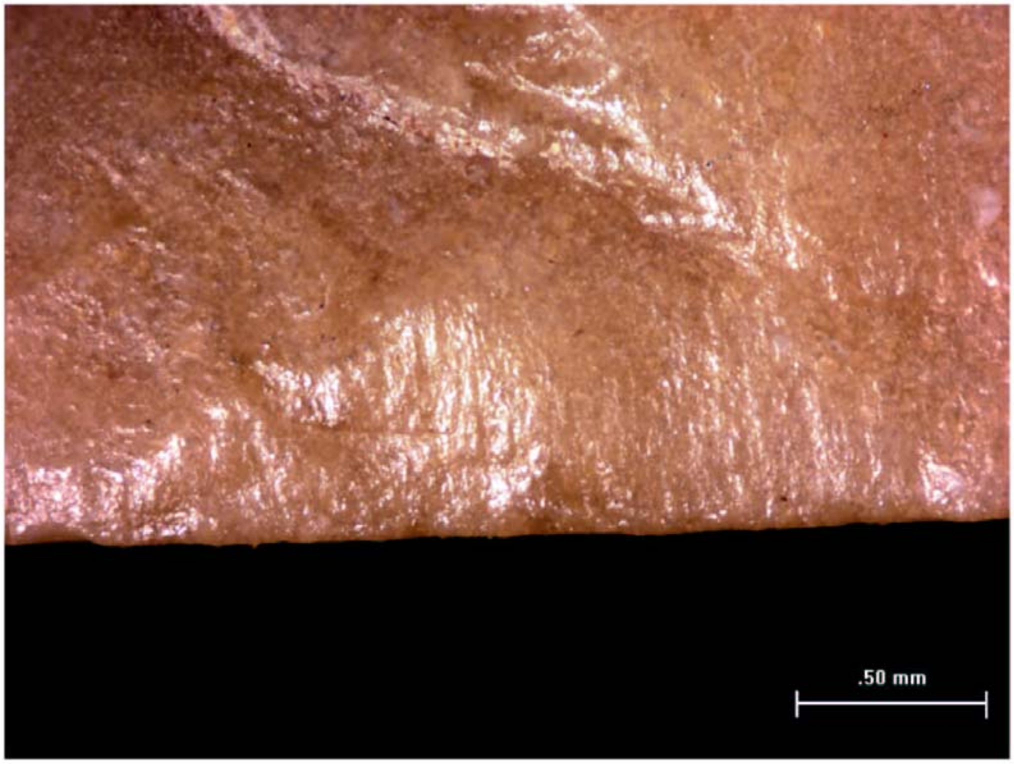


Plate 7, continued. G) Bit edge to the left of center showing abrasion at 40x.

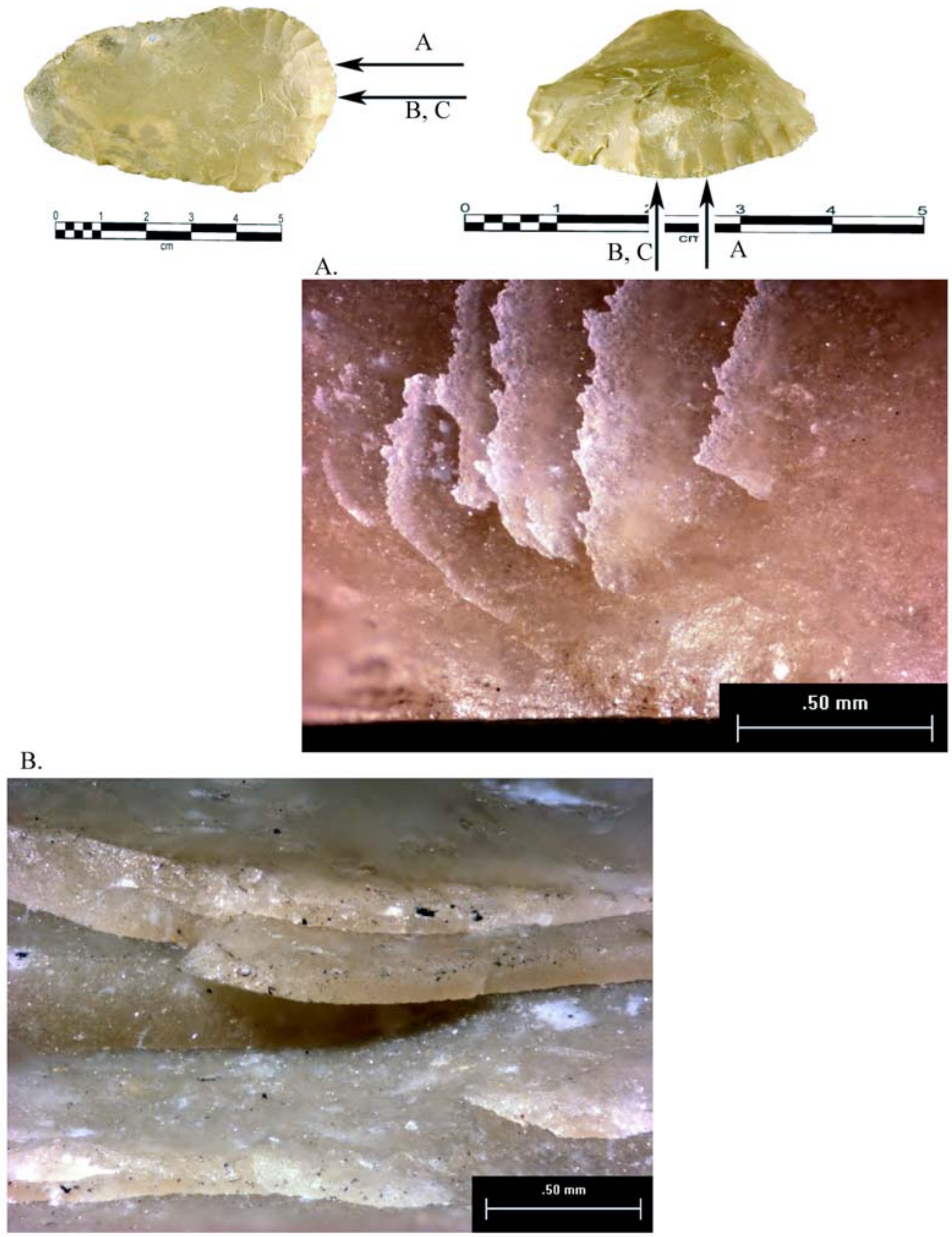
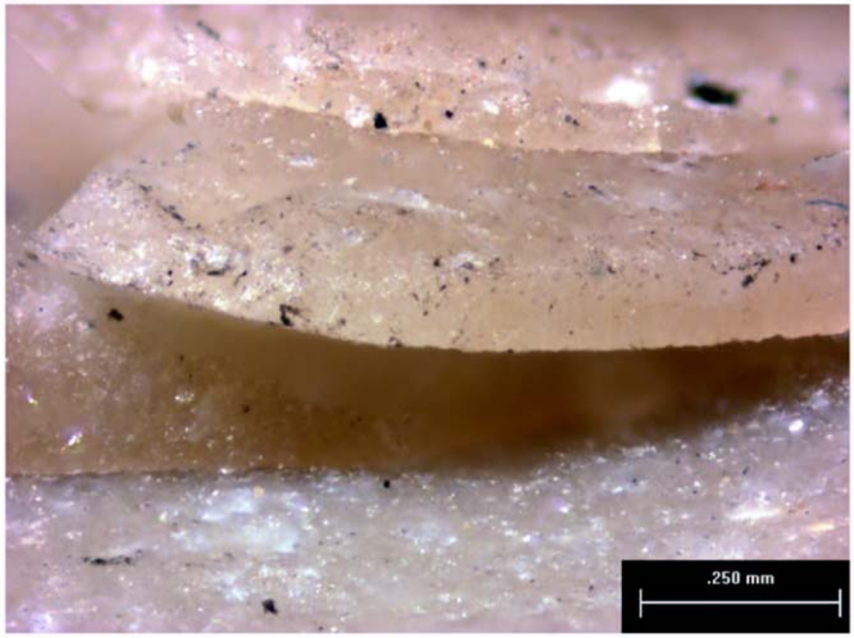


Plate 8. S7 use-wear images. A) Fresh hackles near the center of the bit edge at 65x. B) Step fracture termination scars where the camera angle is almost parallel to the tool surface, and magnification is at 50x.

C.



D.

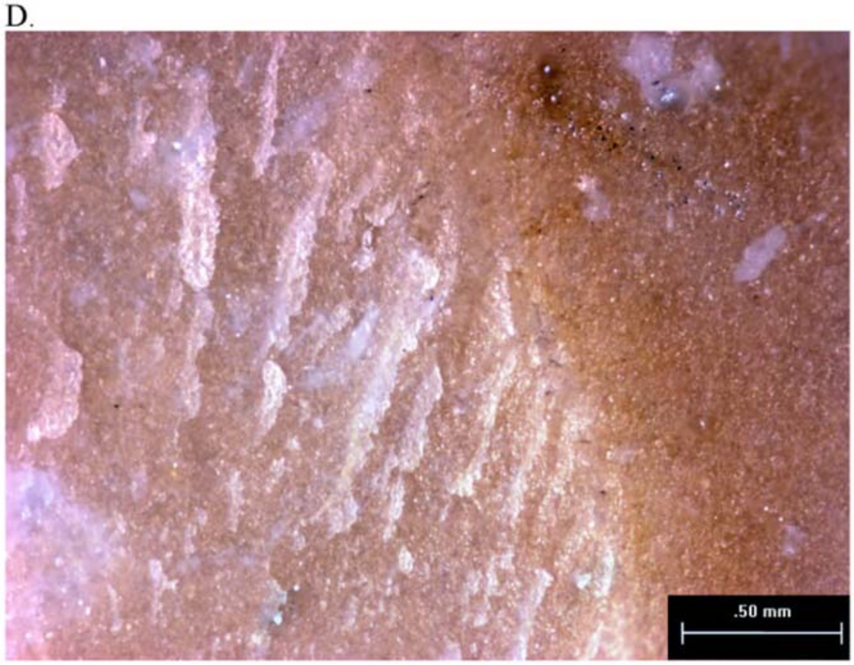


Plate 8, continued. C) The same feature as in B at 100x. D: Fresh flake scar just inland from the bit edge near the center at 45x.

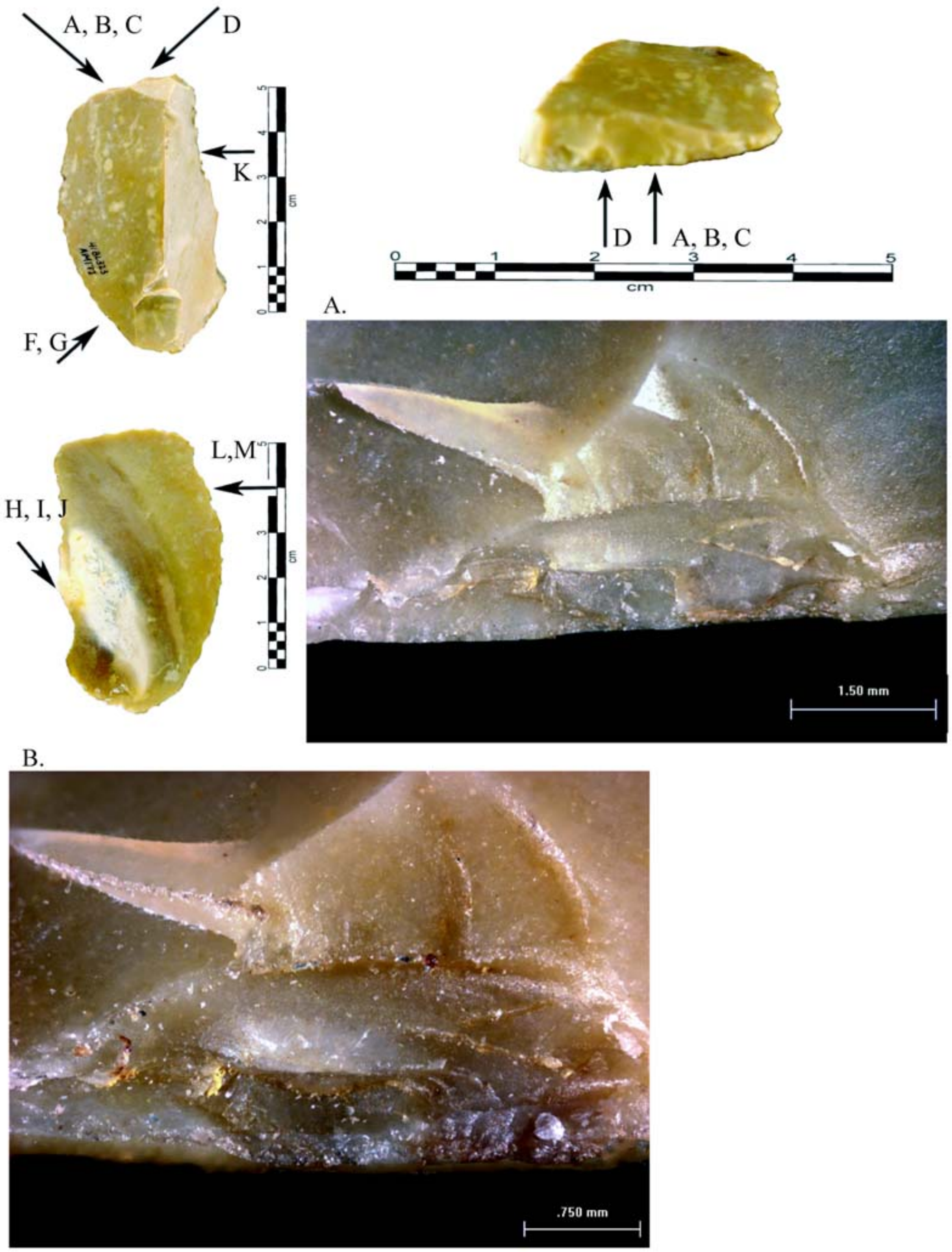
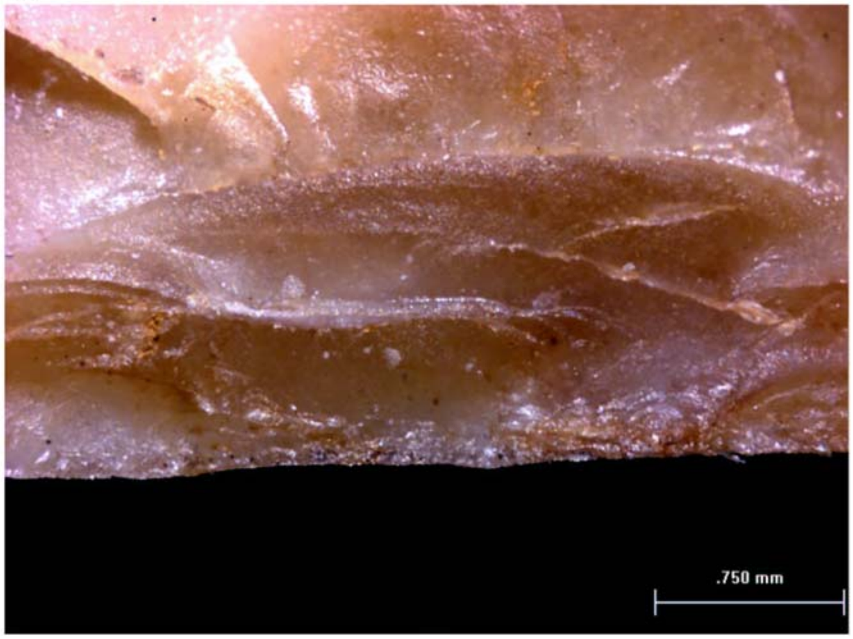


Plate 9. G172 use-wear images. A) Center of the bit edge at 16x. B) The same feature as in A, shown here at a slightly different angle and at 25x.

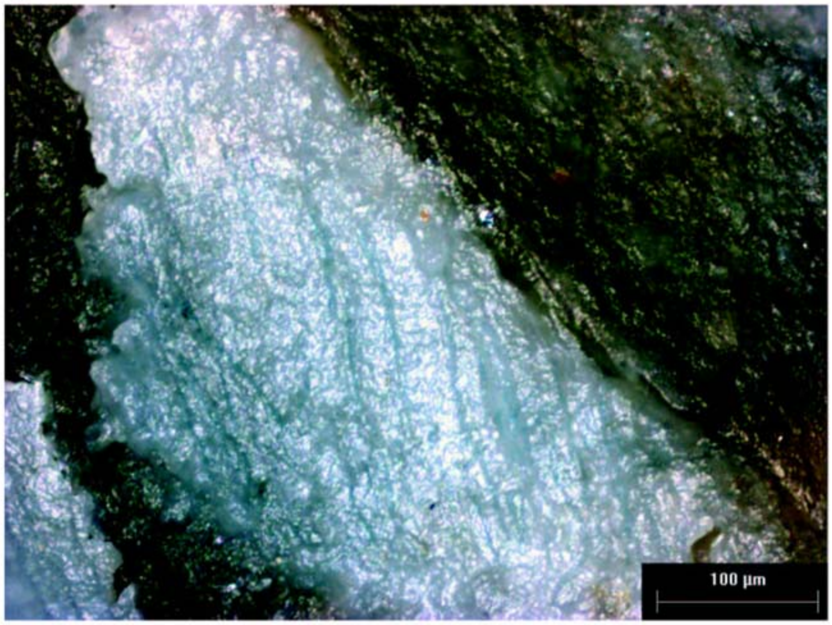
C.



D.

Plate 9, continued. C) The same feature as in A, again at a slightly different angle and at 32x. D) Step fracture terminations at the undercut portion of the bit at 128x.

E.



F.

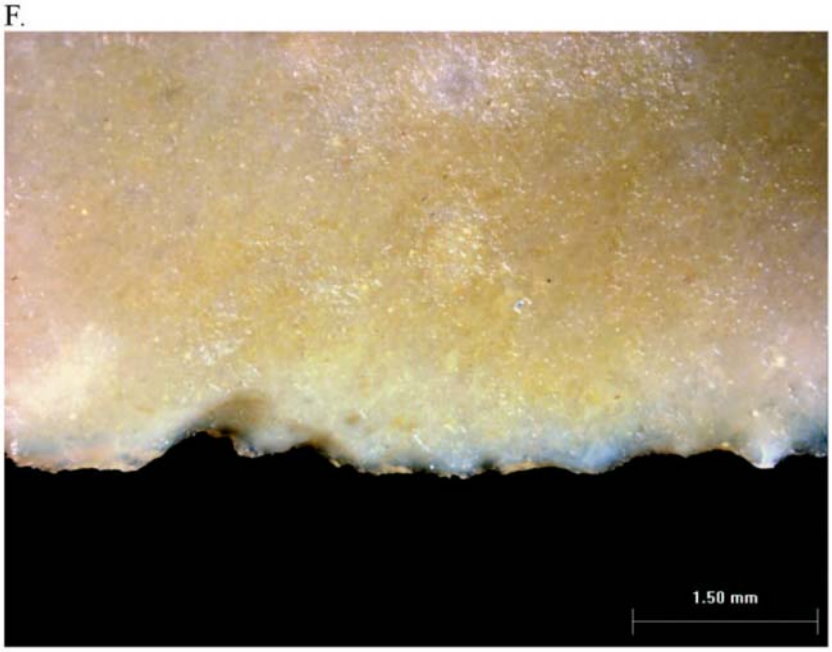
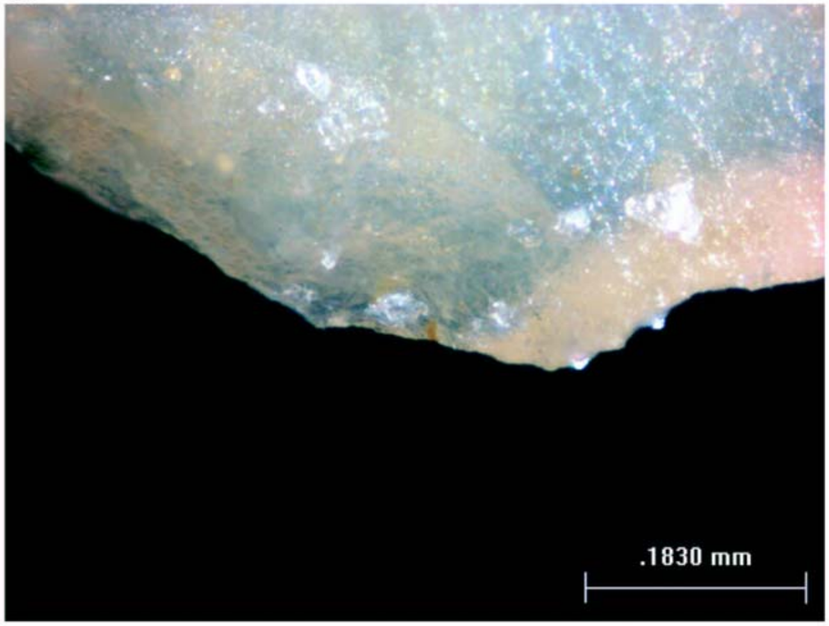


Plate 9, continued. E) Inland from the center of the bit edge at 200x.
F) Left lateral edge at 16x.

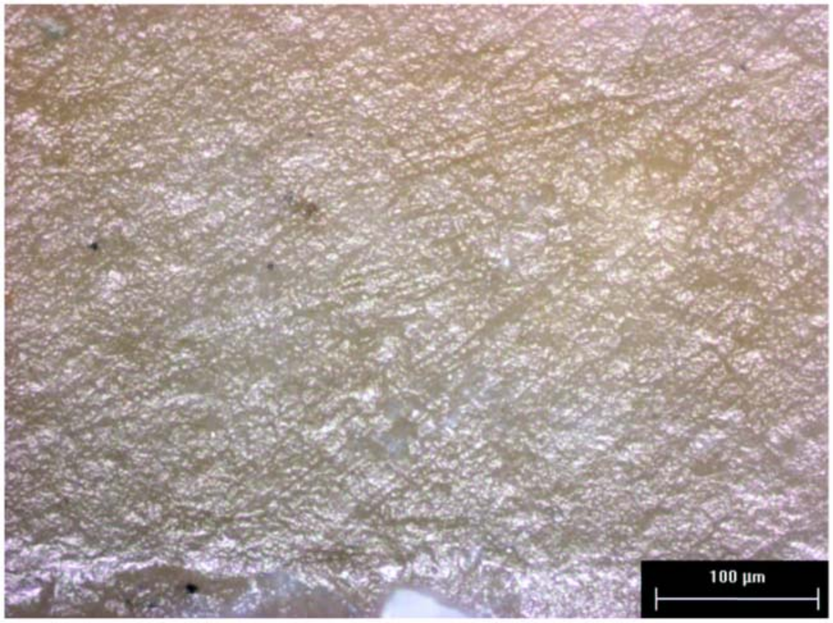
G.



H.

Plate 9, continued. G) Left lateral edge at 160x, in the same area as F.
H) The ventral side of the right lateral edge at 100x.

I.



J.

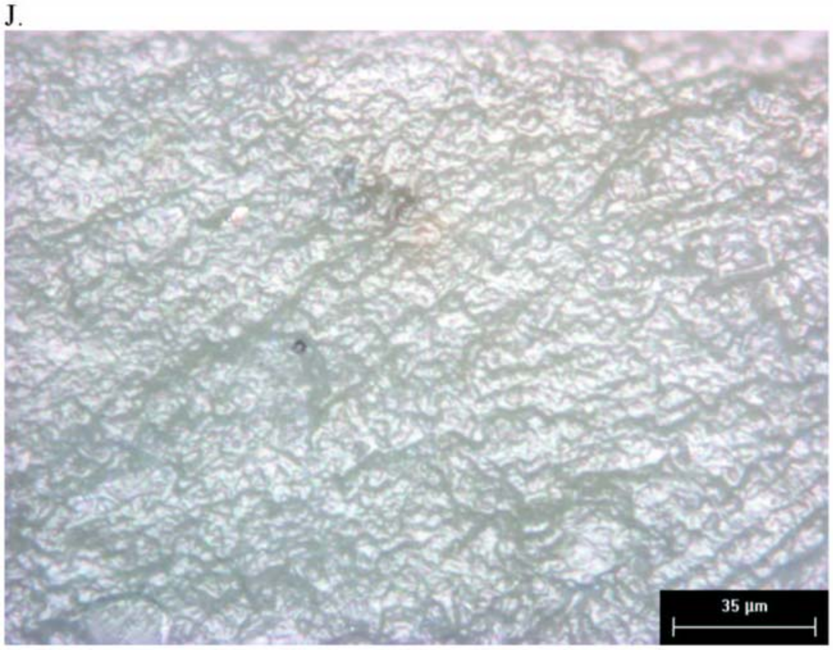
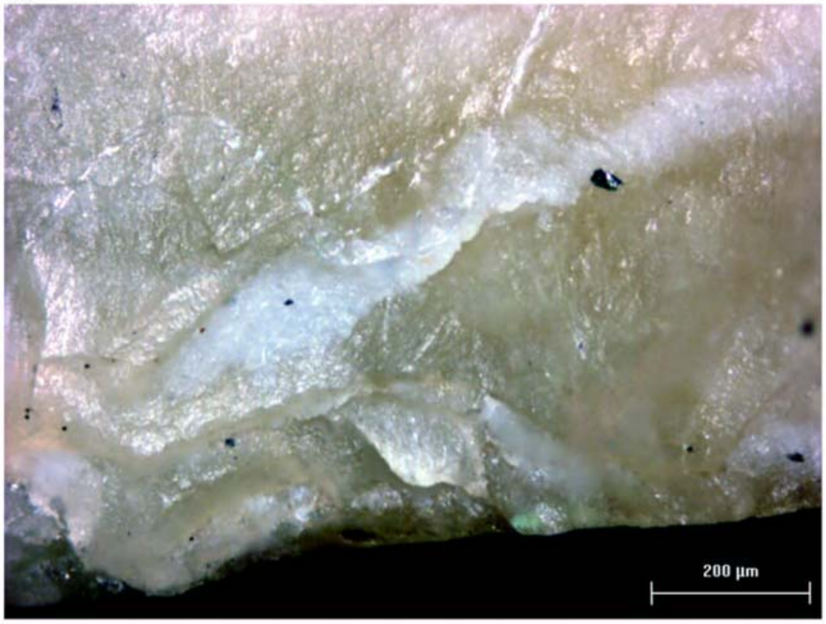


Plate 9, continued. I) The same location as H, shown here at 200x.
J) The same location as H again, here at 500x.

K.



L.

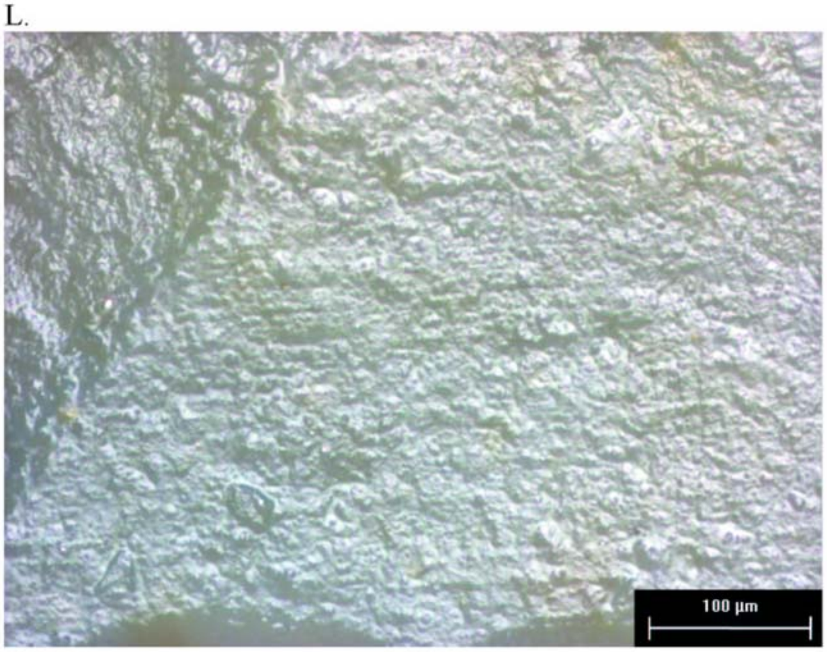


Plate 9, continued. K) Projection on the right lateral edge at 100x.
L) Proximal left lateral edge on the ventral side at 200x.

M.

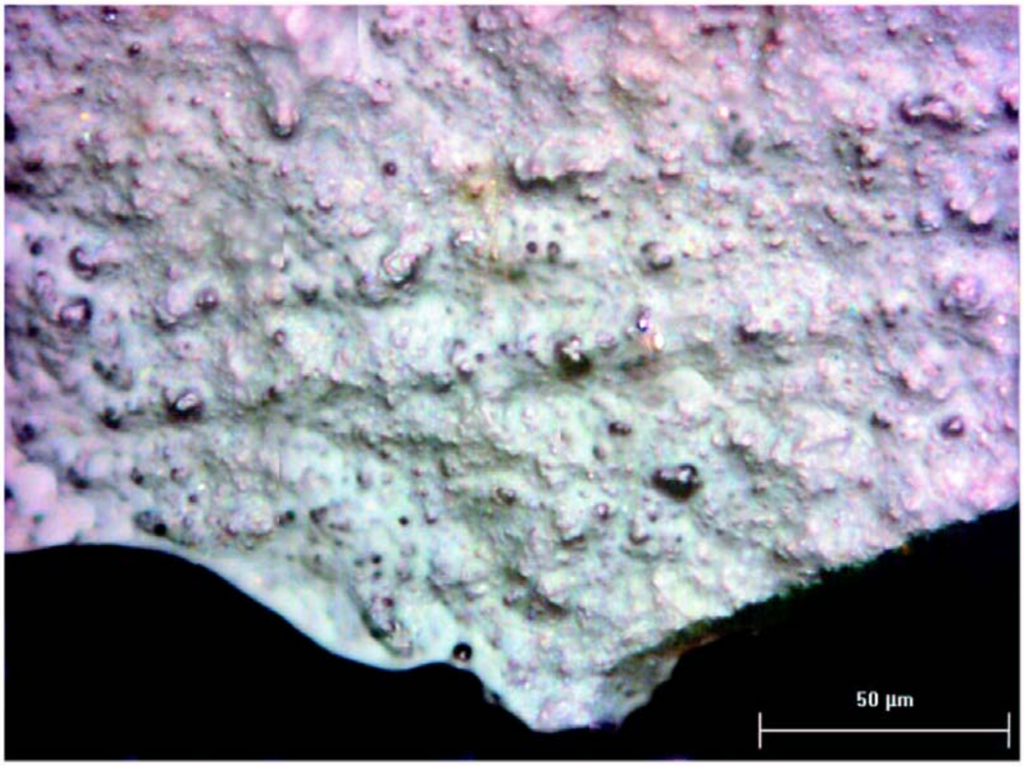


Plate 9, continued. M) The same location as in L, but nearer the edge and shown here at 500x.

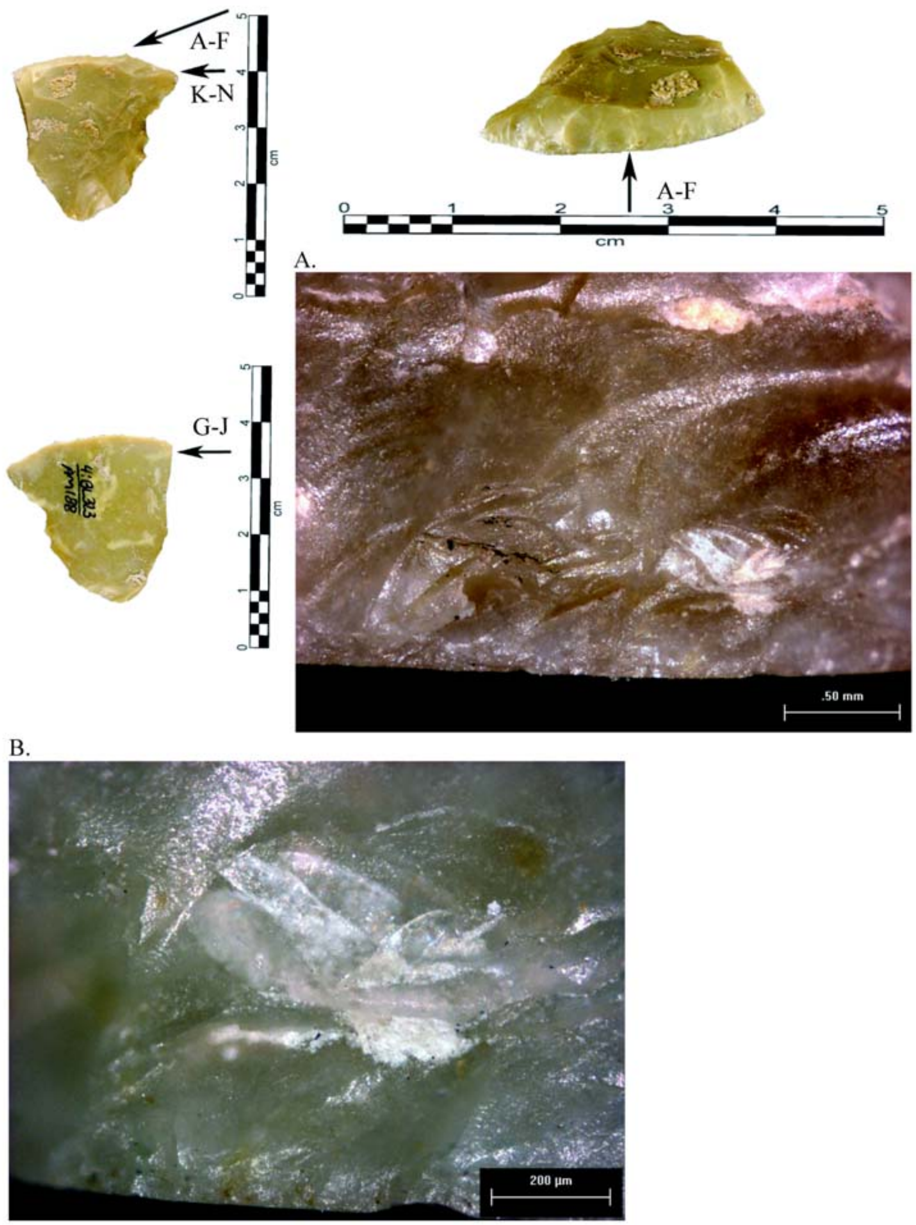
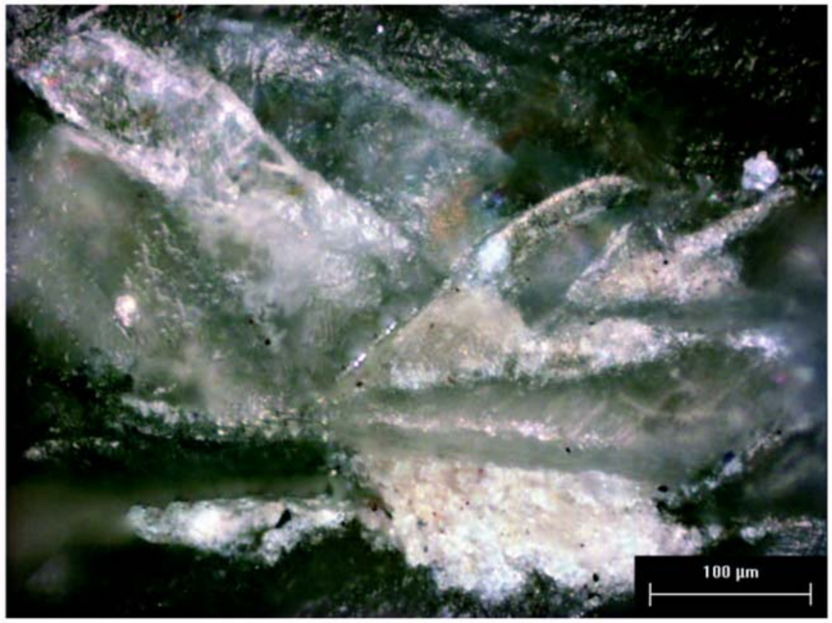


Plate 10. G188 use-wear images. A) Center of bit edge at 40x. B) Feature in the lower right-hand portion of A shown here at 100x.

C.



D.

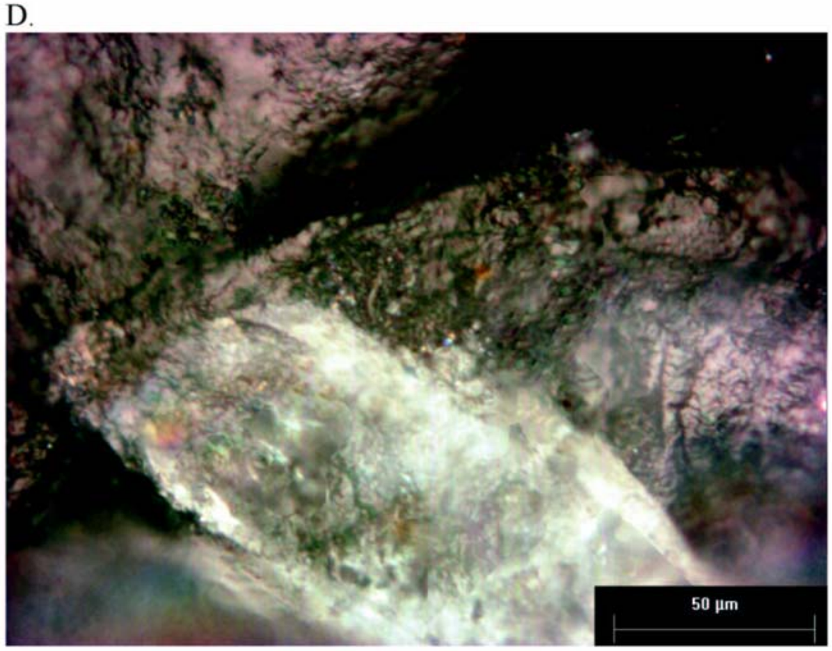
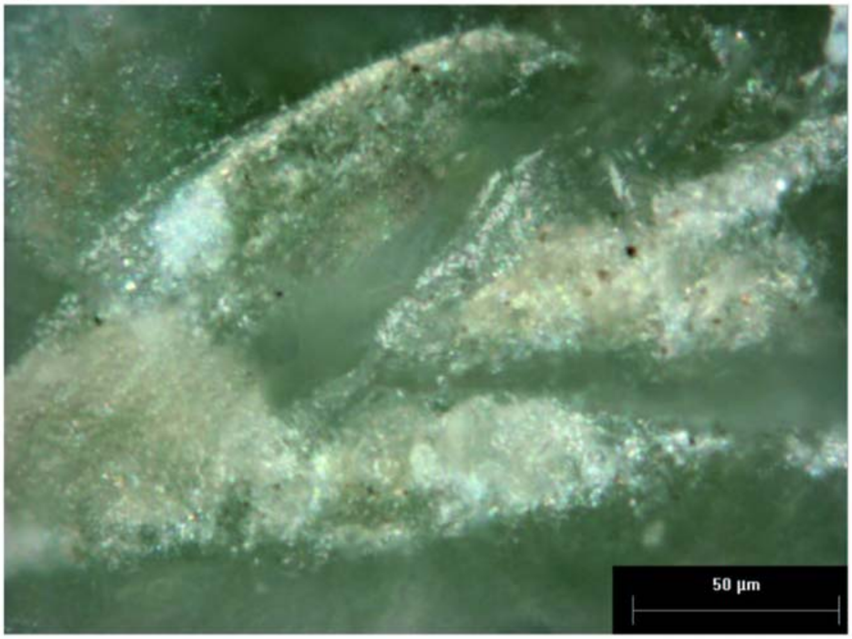


Plate 10, continued. C) Same feature as in the two previous images shown here at 200x. D) The upper left portion of the feature in C at 500x.

E.



F.

Plate 10, continued. E) The right center portion of C at 500x. F) View of the center bit edge froma slightly different angle than that in the previous images shown here at 160c.

G.

H.

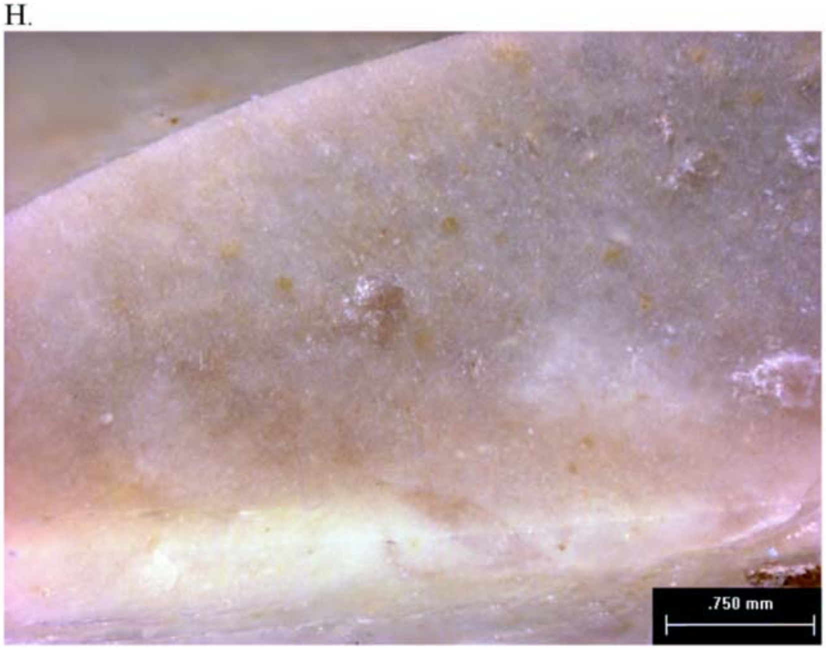


Plate 10, continued. G) Lateral view of truncated left spur surface and ventral edge at 16x. H) The same feature as in G shown at 25x.

I.

J.

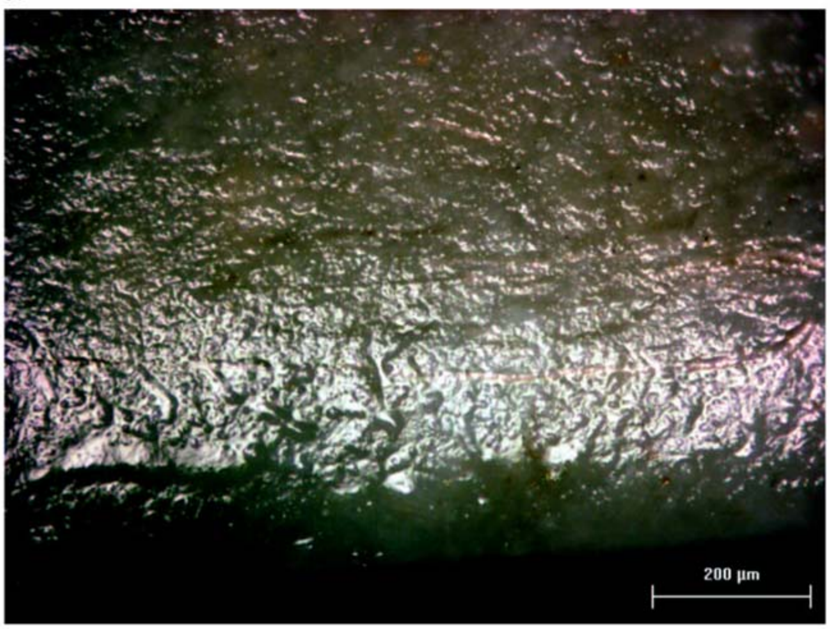
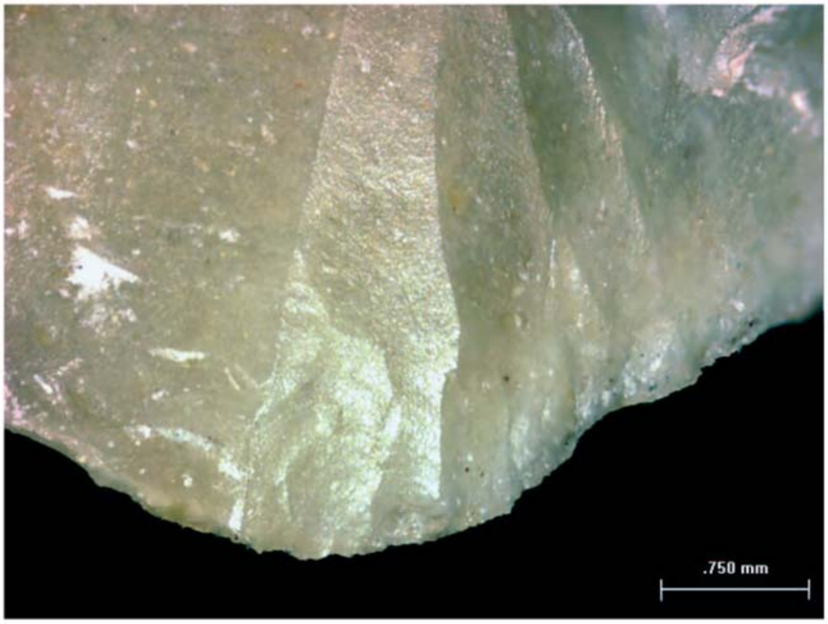


Plate 10, continued. I) The ventral edge of the left spur area at 40x. J) Rounding on the extreme ventral edge of the left spur at 100x.

K.



L.

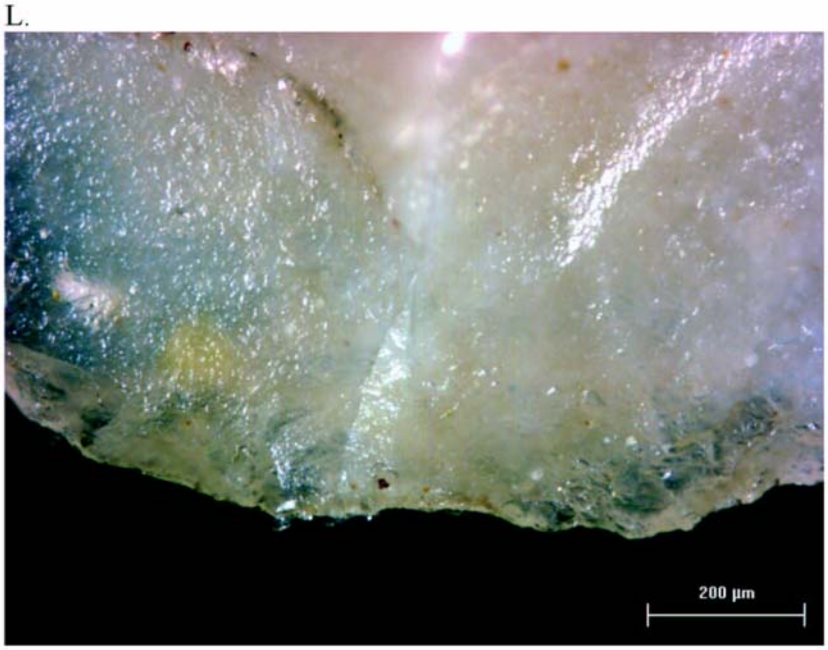
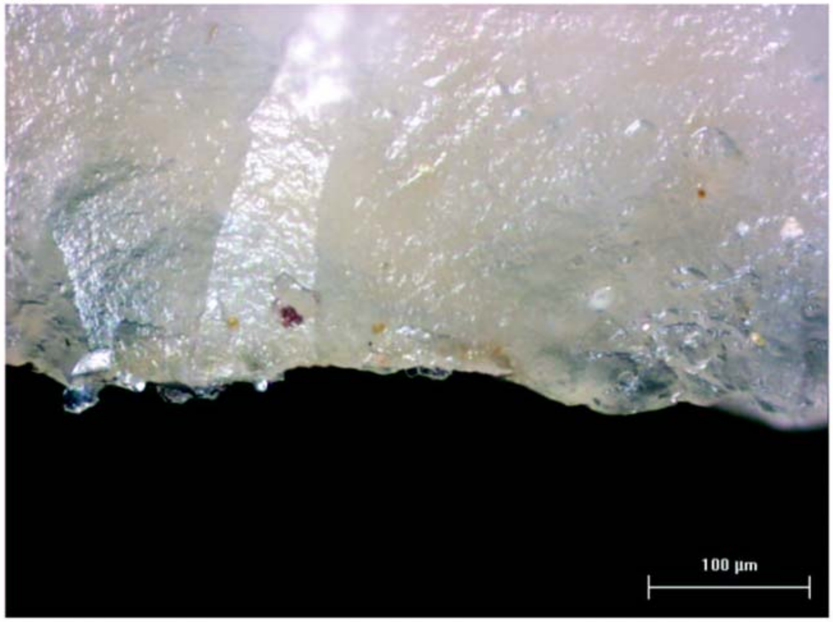


Plate 10, continued. K) The right spur tip, dorsal side at 25x.
L) The same area at 100x.

M.



N.

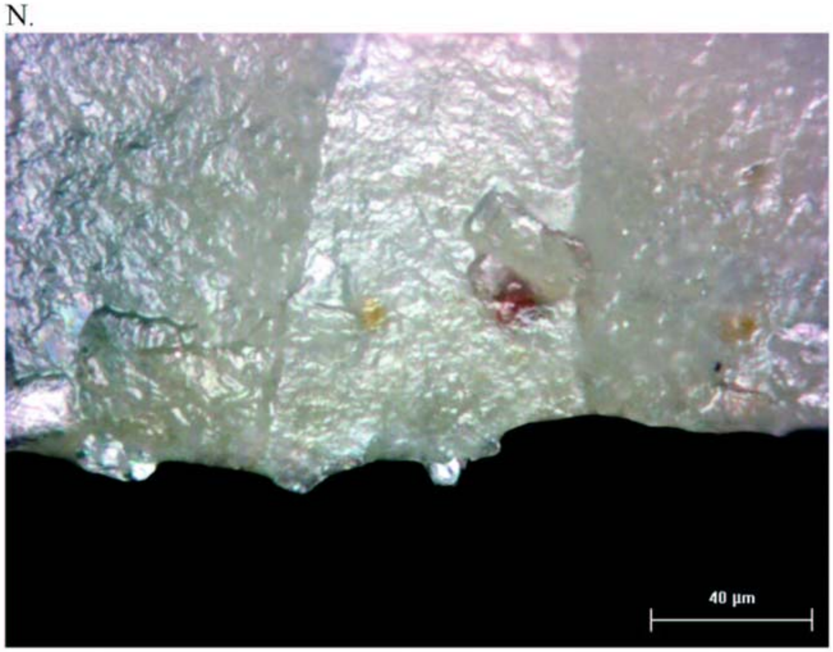


Plate 10, continued. M) The same area as in K and L, but at a slightly different angle and at 200x. N) The same feature as in N at 500x.

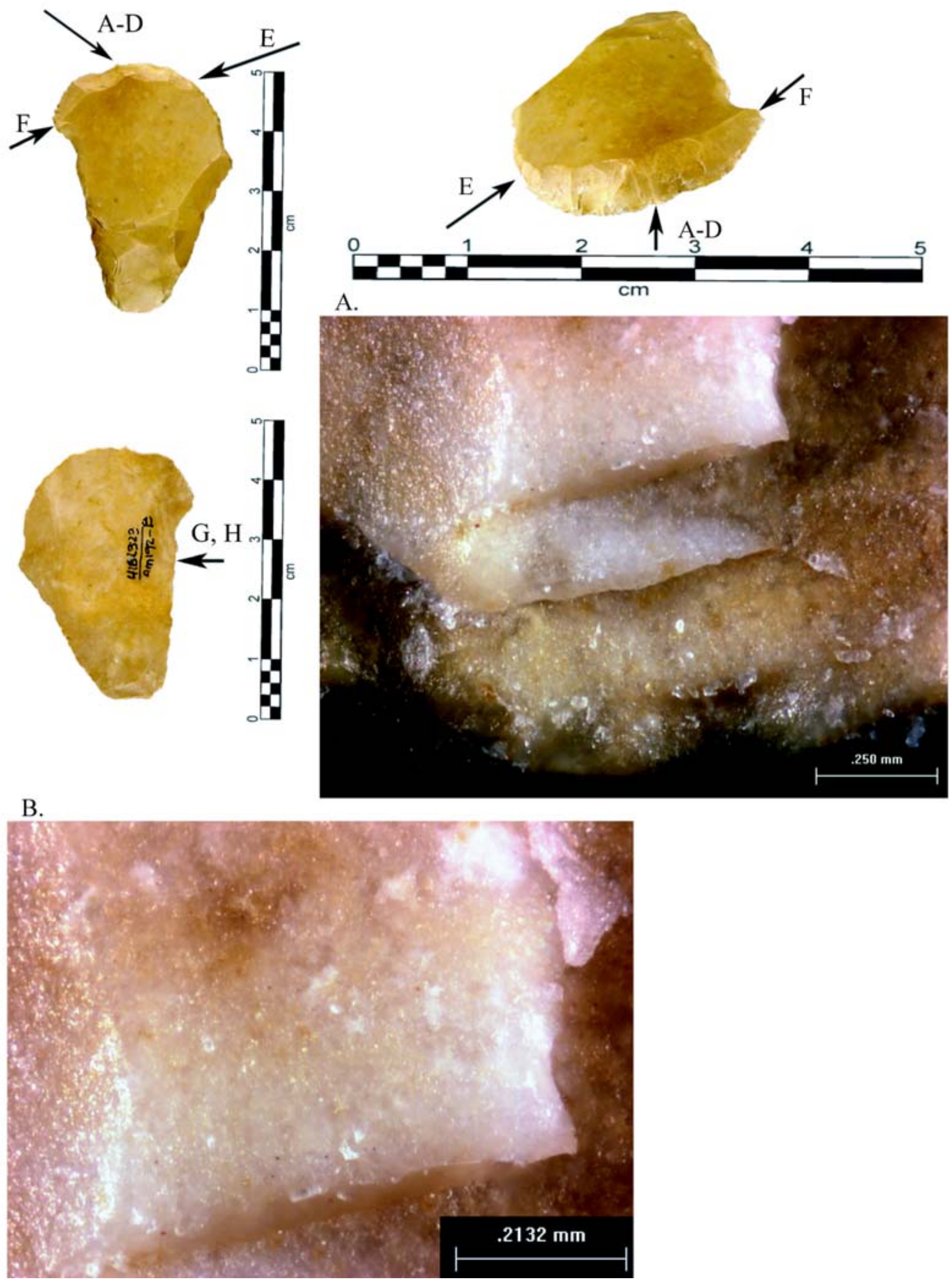


Plate 11. G192B use-wear images. A) The center of the bit edge at 80x. B) The upper step fracture termination in A at 128x.

C.

D.

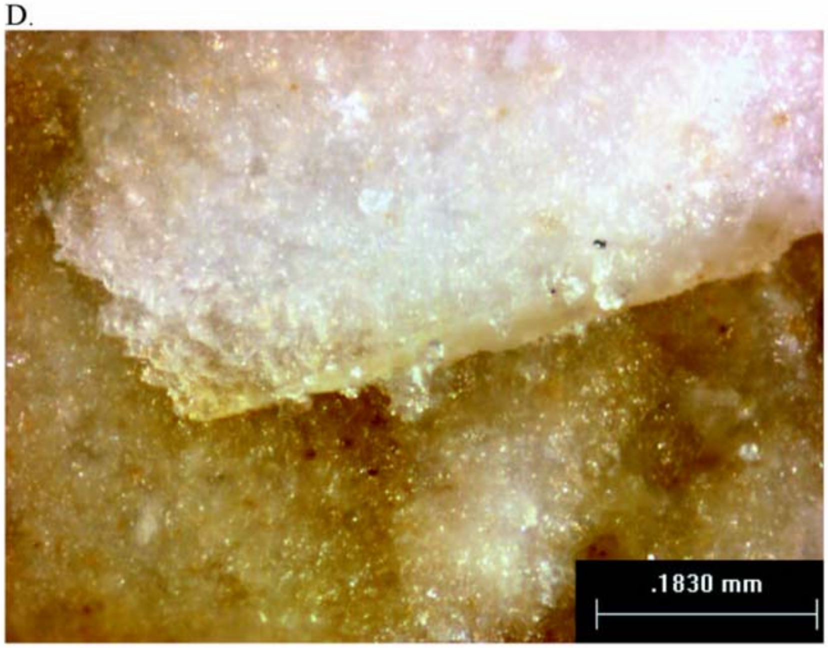


Plate 11, continued. C) Series of step fracture terminations near the center of the bit edge at 128x. D) The left end of the upper step fracture termination in C, shown here at 160x.

E.

F.

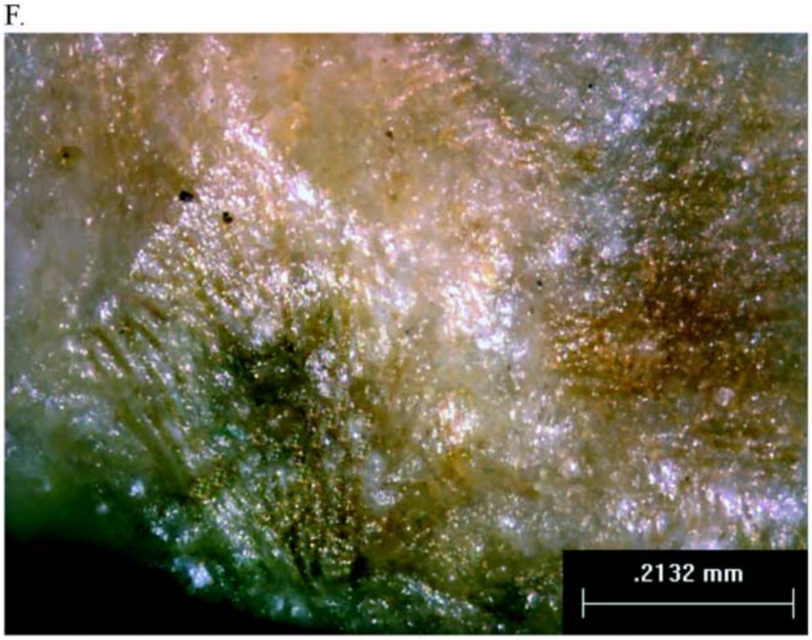
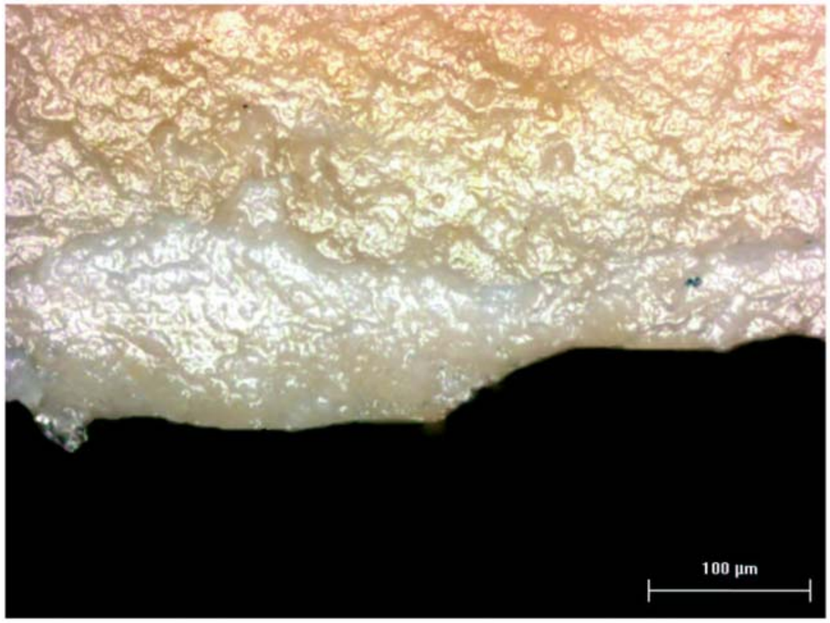


Plate 11, continued. E) Feature similar to that found on S5 and depicted in images J-J in Plate 6. Its location is at the far right of the bit edge and is shown here at 200x. F) Face of the left spur tip at 129x.

G.



H.

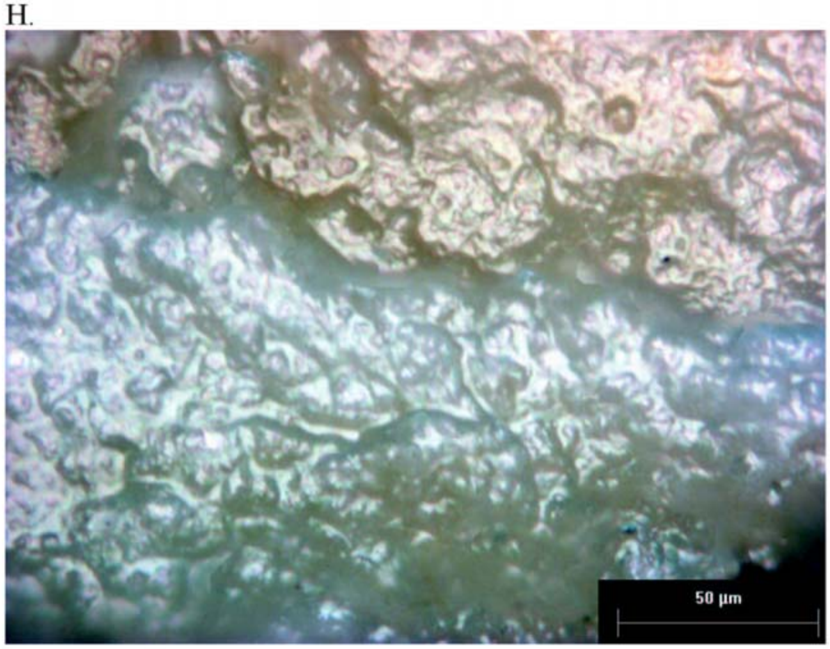


Plate 11, continued. G) The left lateral edge, ventral side at 200x. H) The same feature at 500x.

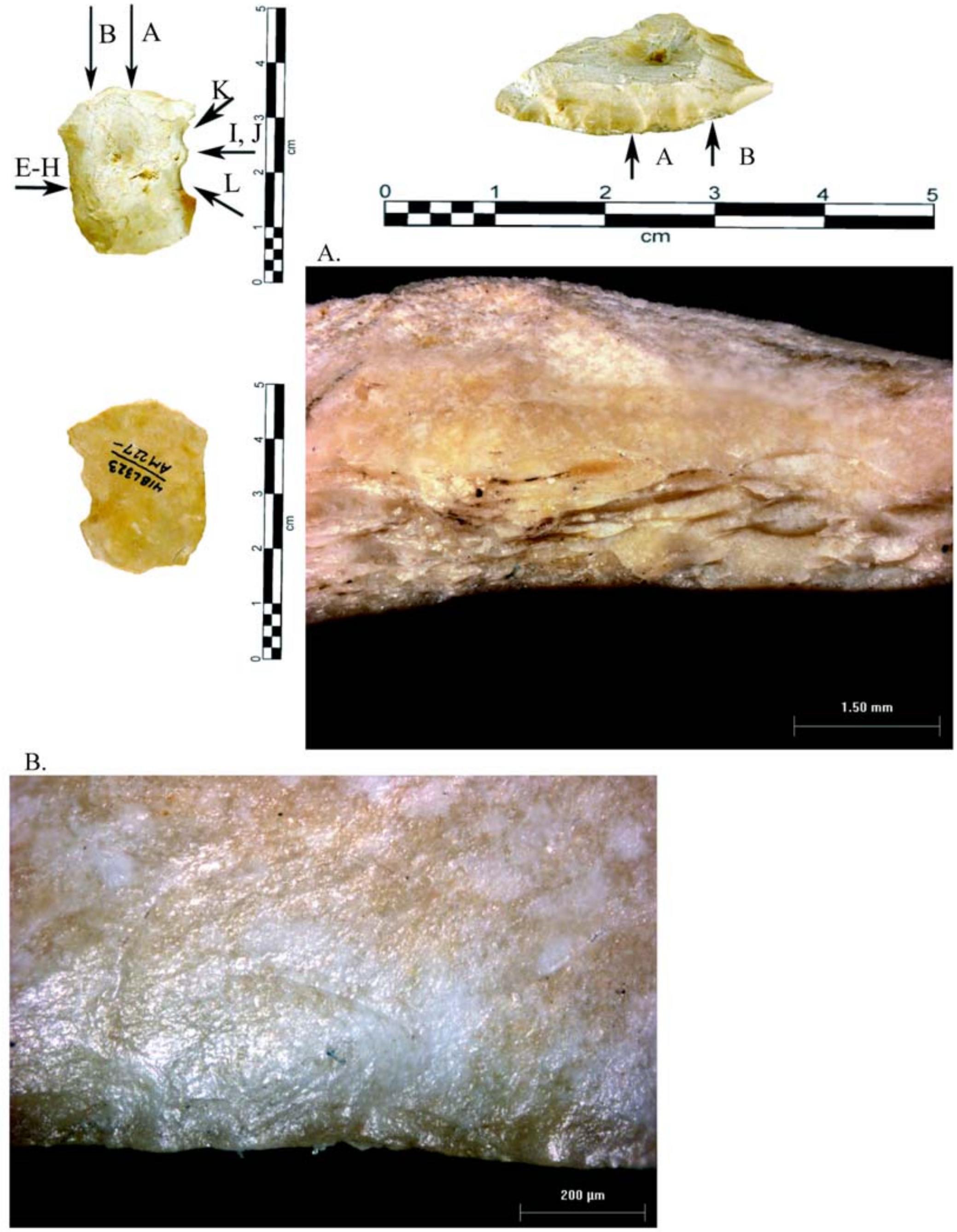
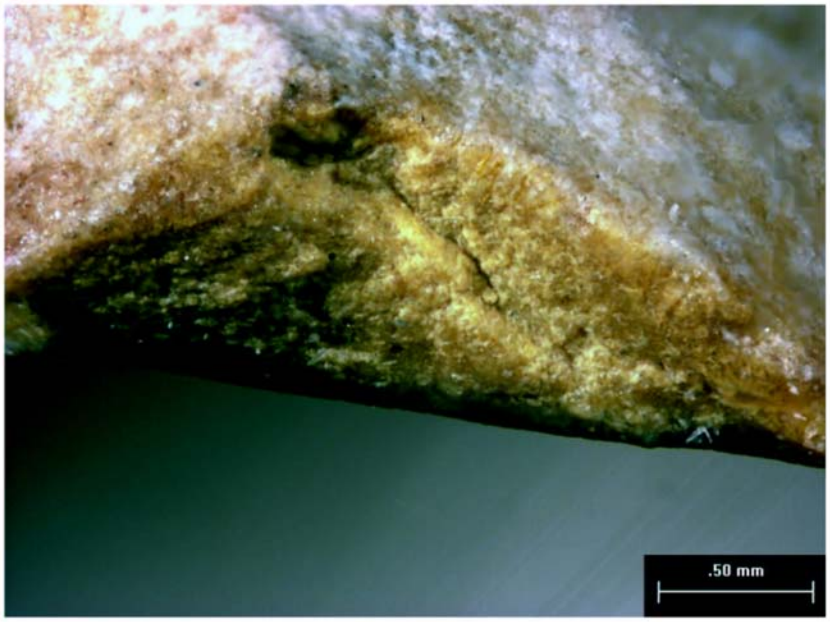


Plate 12. G277 use-wear images. A) Center of the bit edge at 16x.
B) Bit edge to the left of center at 100x.

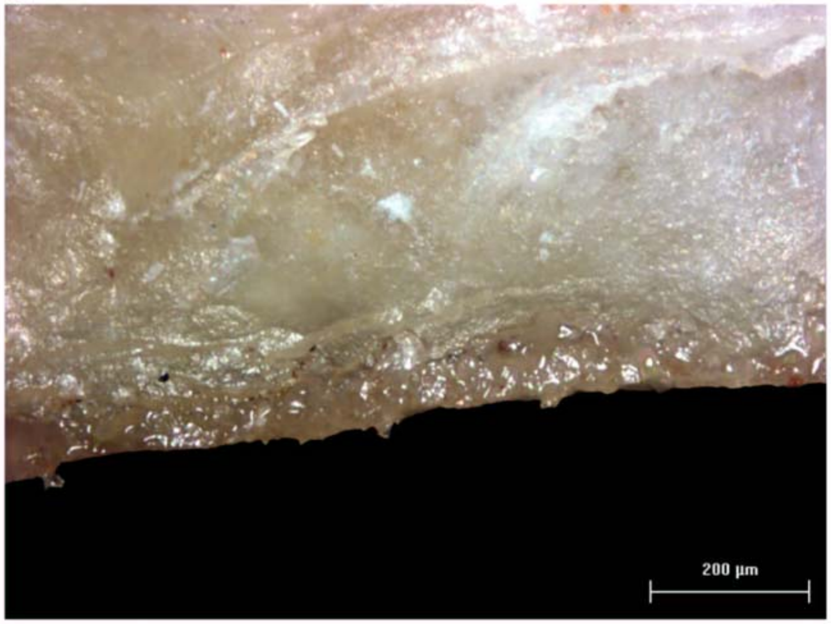
C.



D.

Plate 12, continued. C) Right spur tip at 40x. D) Right spur tip shown from a different angle at 50x.

E.



F.

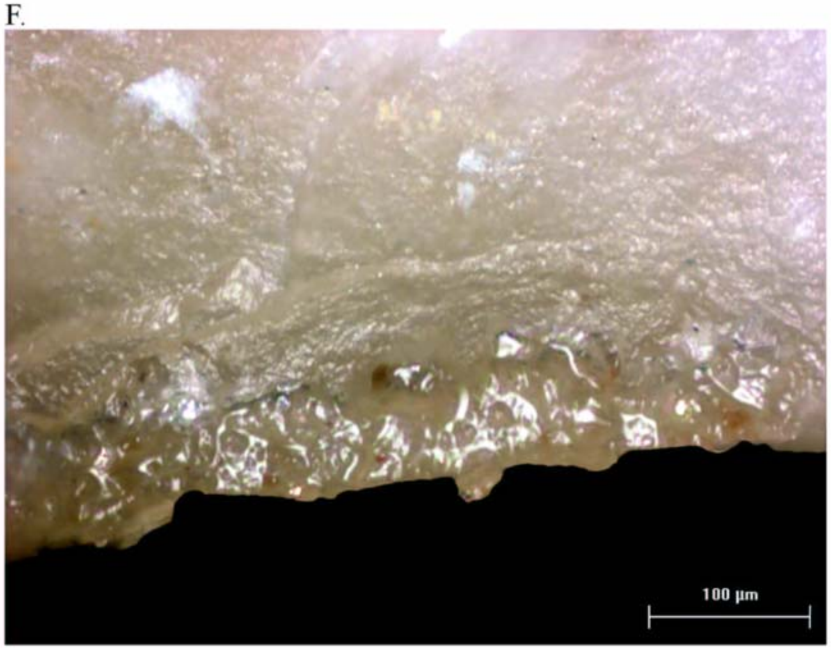
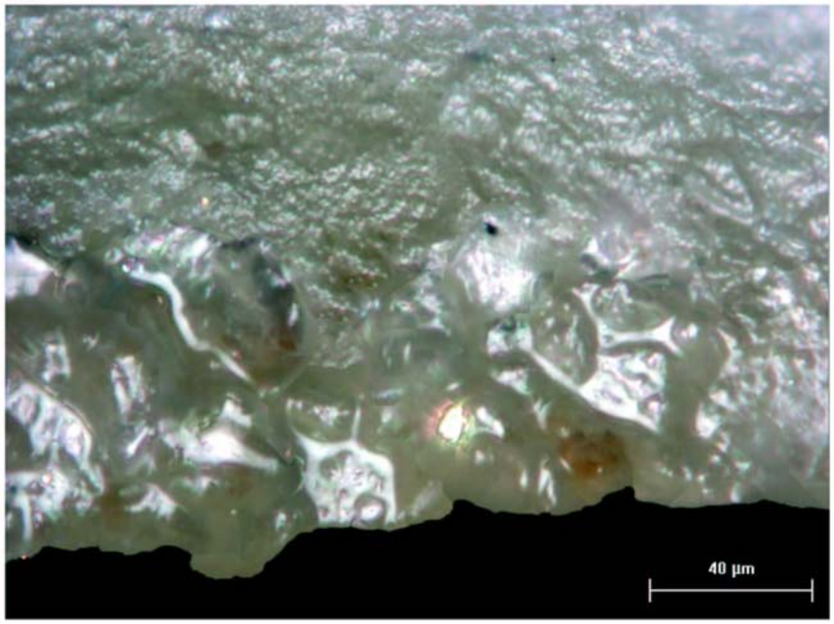


Plate 12, continued. E) Left lateral edge at 100x.
F) The center of the area in E magnified to 200x.

G.



H.

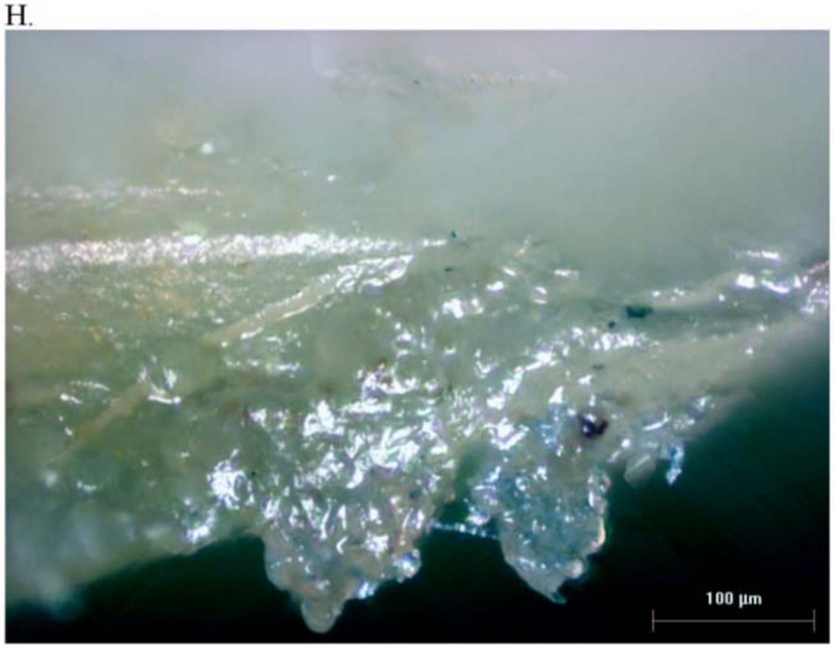
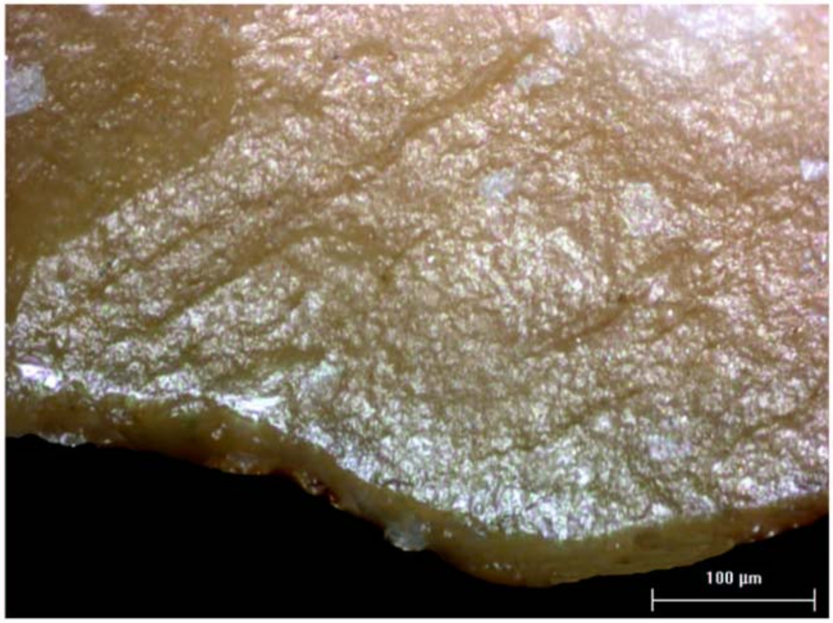


Plate 12, continued. G) The same area as in E and F, shown here at 500x.
H) The left lateral edge sat a different location and angle, show at 200x.

I.



J.

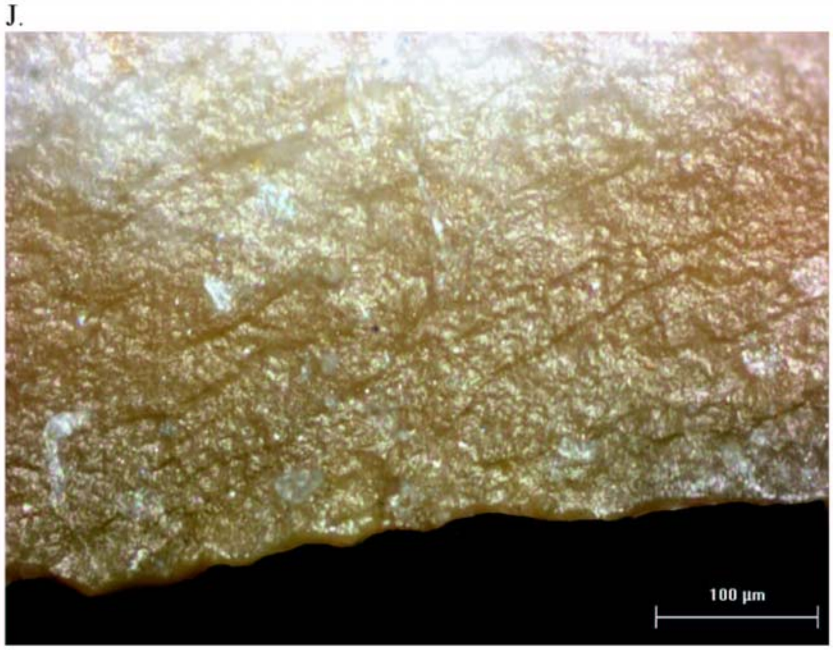


Plate 12, continued. I) Projection on right lateral edge t 200x. J) The same area at 200x at a slightly different angle and location.

K.

L.

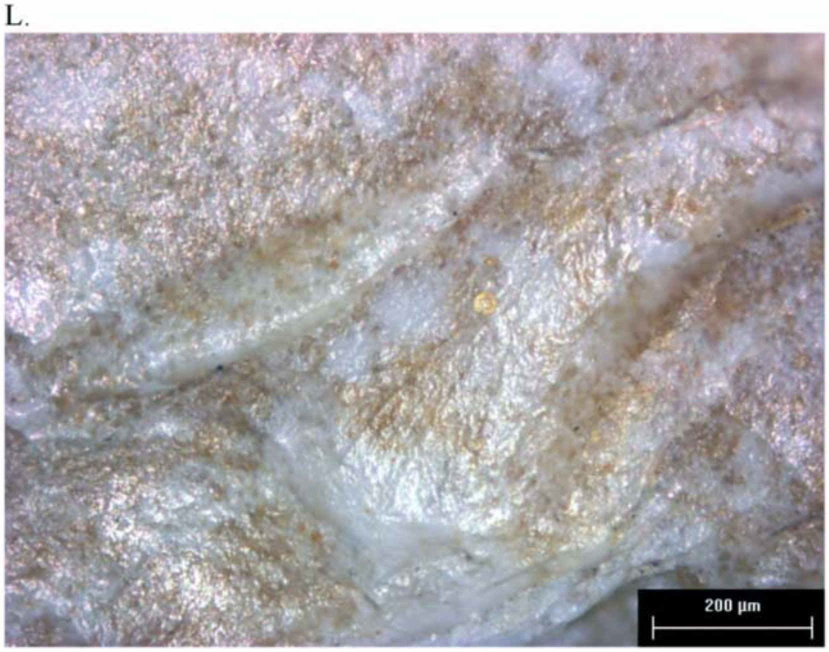


Plate 12, continued. K) The edge of the proximal right lateral notch at 100x. L) Just inland from the edge on the dorsal surface of the distal right lateral notch at 100x.

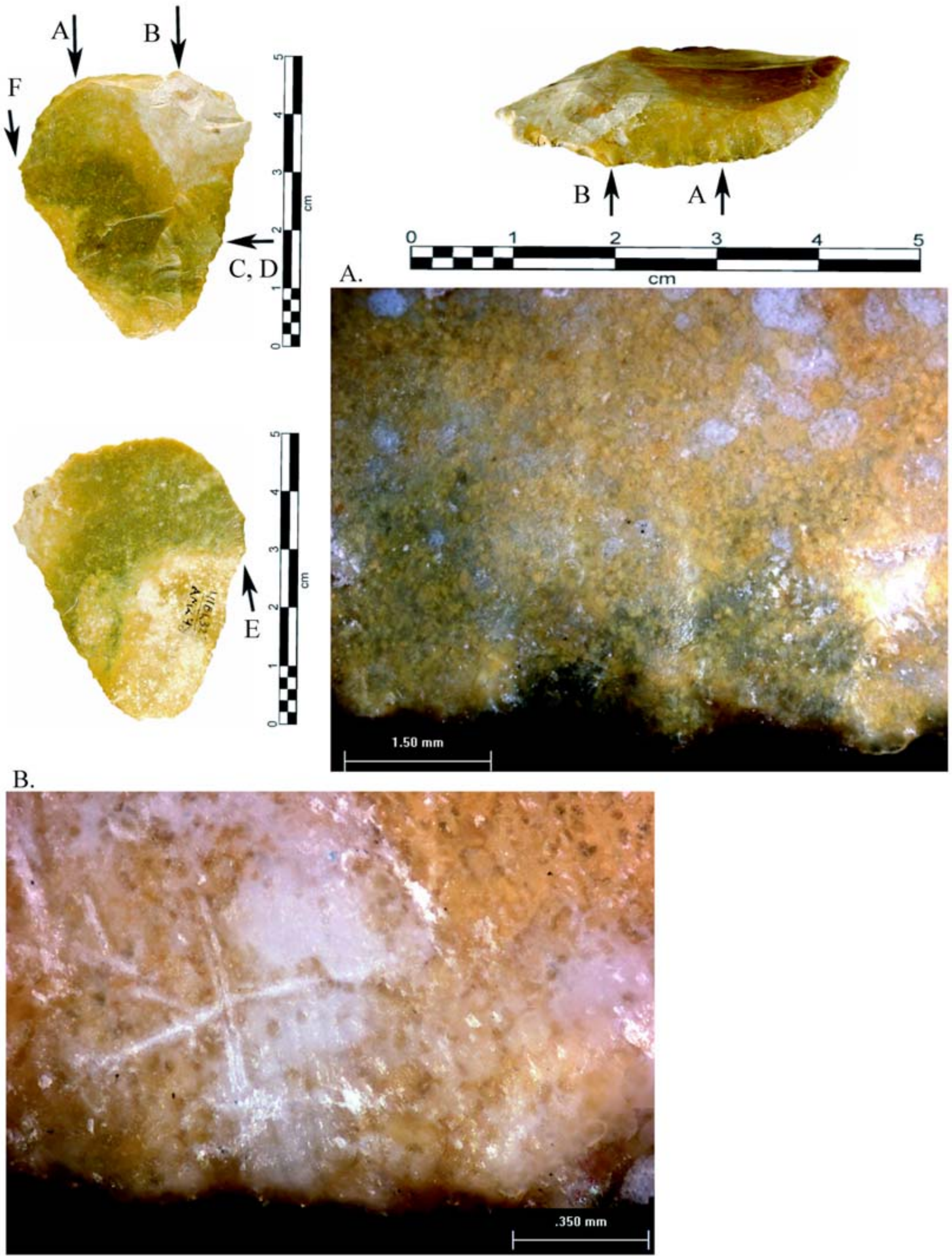
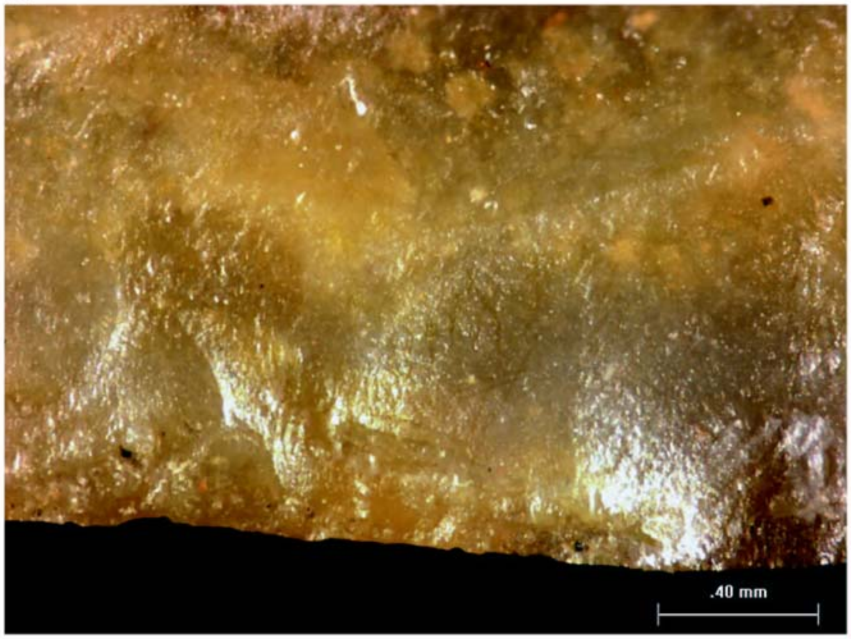


Plate 13. G248A use-wear images. A) Left center of the bit edge at 16x.
B) Projection to the right of the bit edge center at 64x.

C.



D.

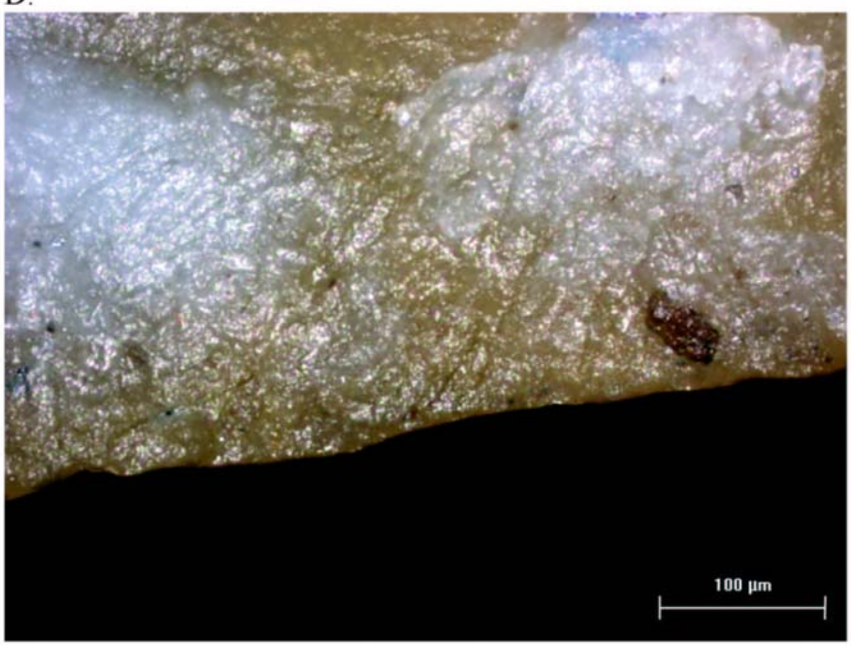
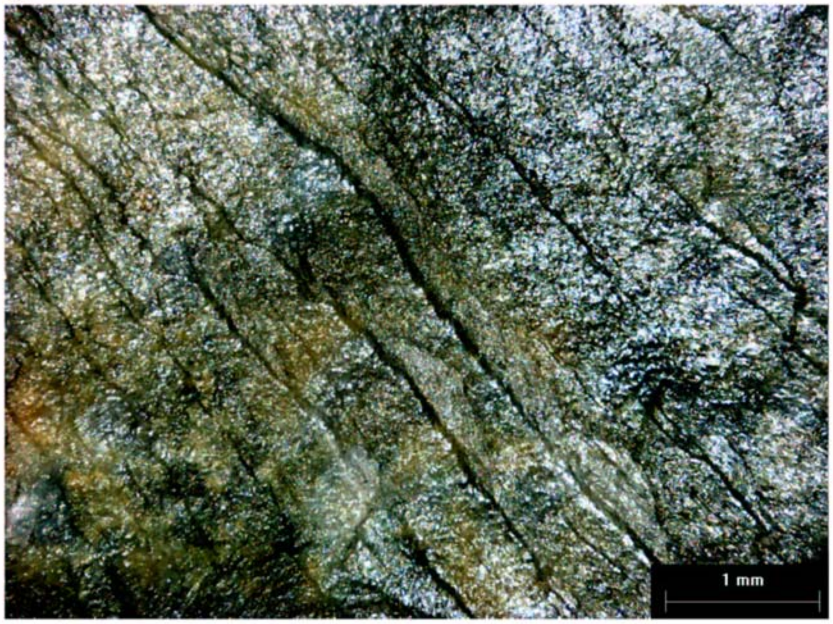


Plate 13, continued. C) Right lateral edge at 50x. D) A different area of the right lateral edge at 200x.

E.



F.

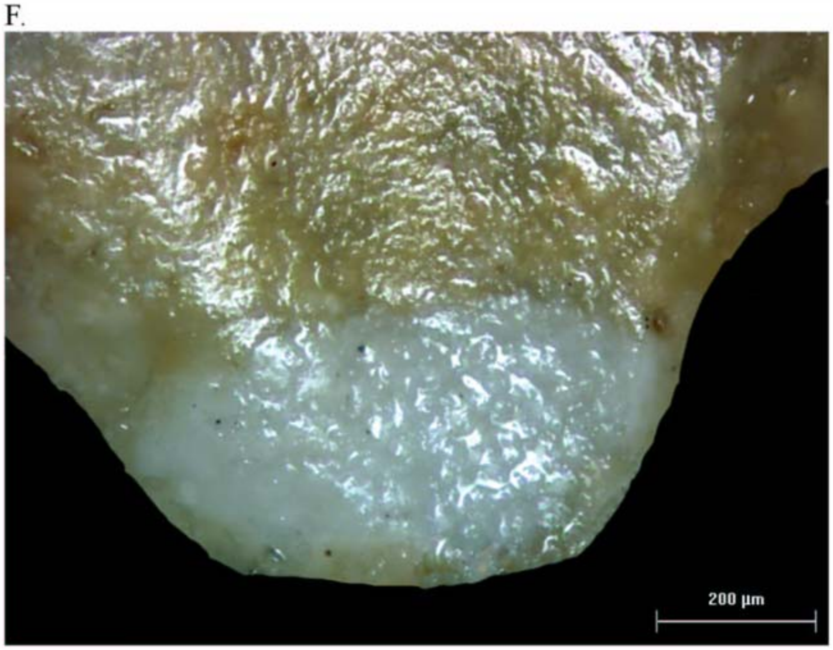


Plate 13, continued. E) The ventral surface of the left spur area at 20x.
F) Projection at left spur tip at 100x.

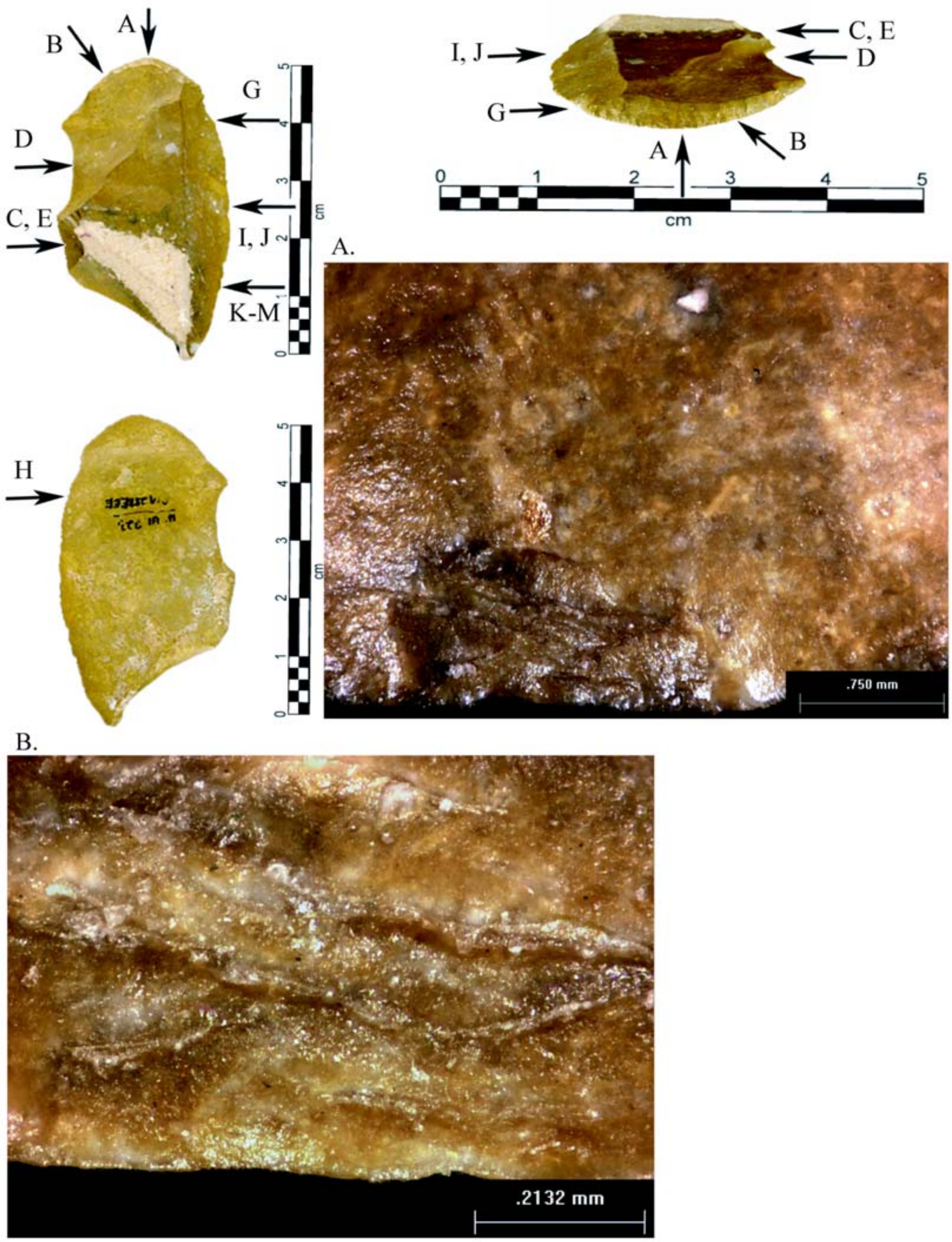
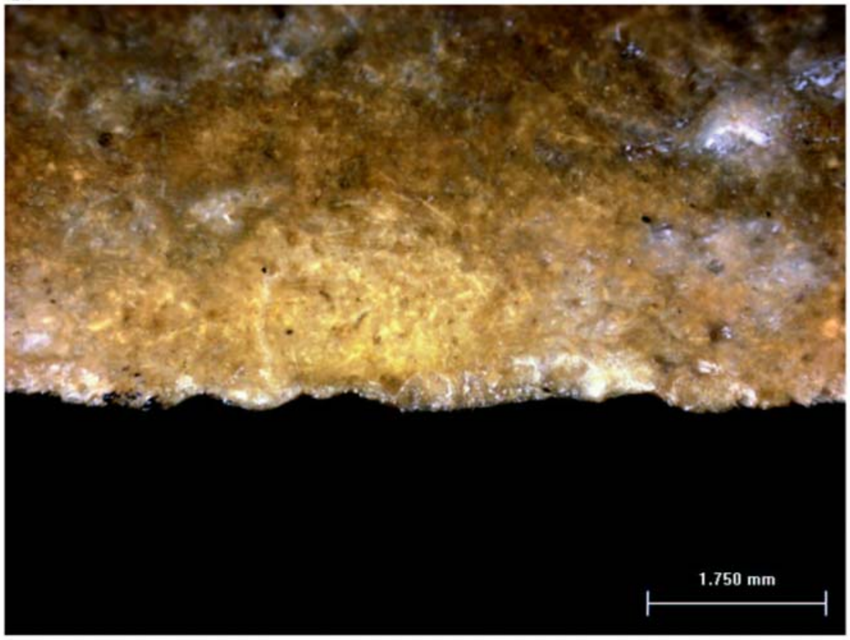


Plate 14. G288EEE use-wear images. A) Center of the bit edge at 32x.
B) Just left of the center bit edge at 80x.

C.



D.

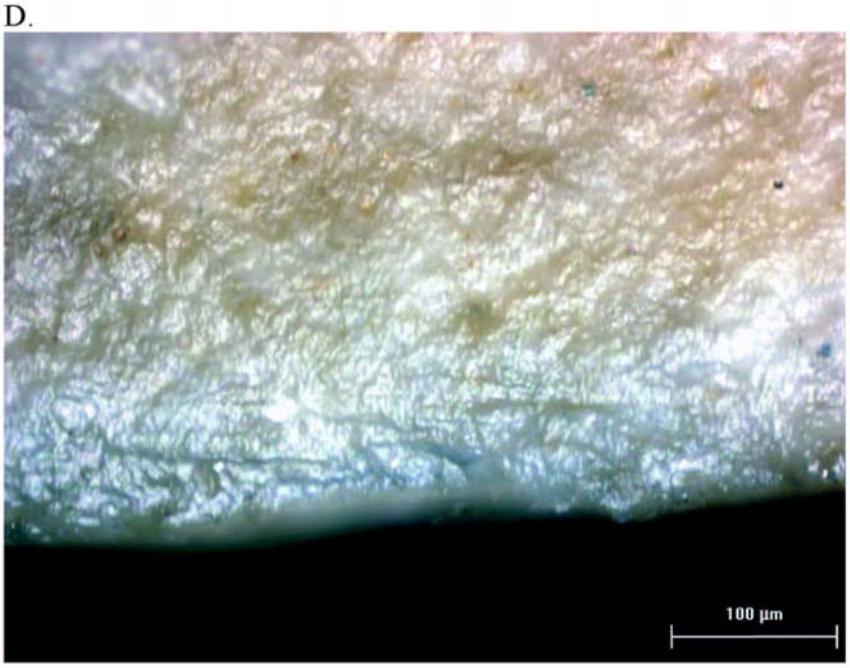
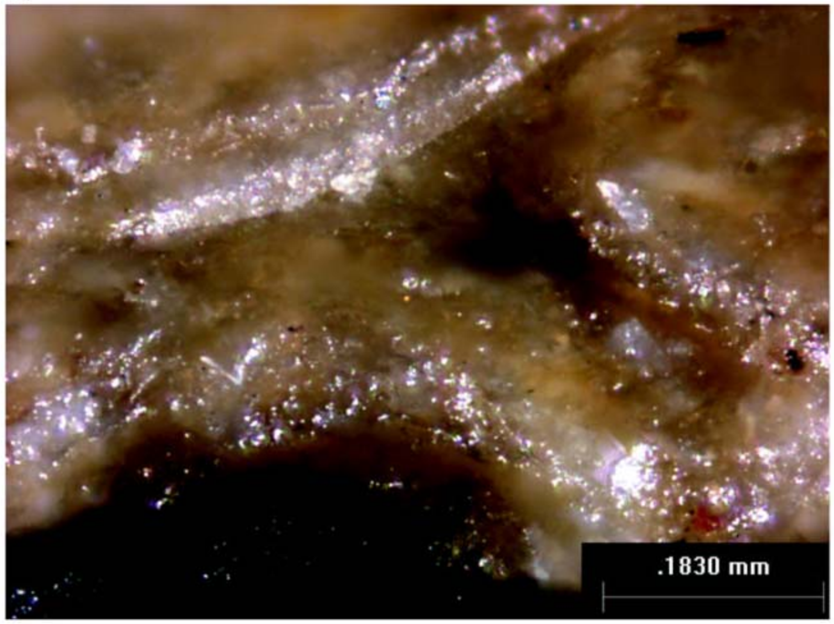


Plate 14, continued. C) Left lateral edge at 12x. D) In the notch on the left lateral edge at 200x.

E.



F.

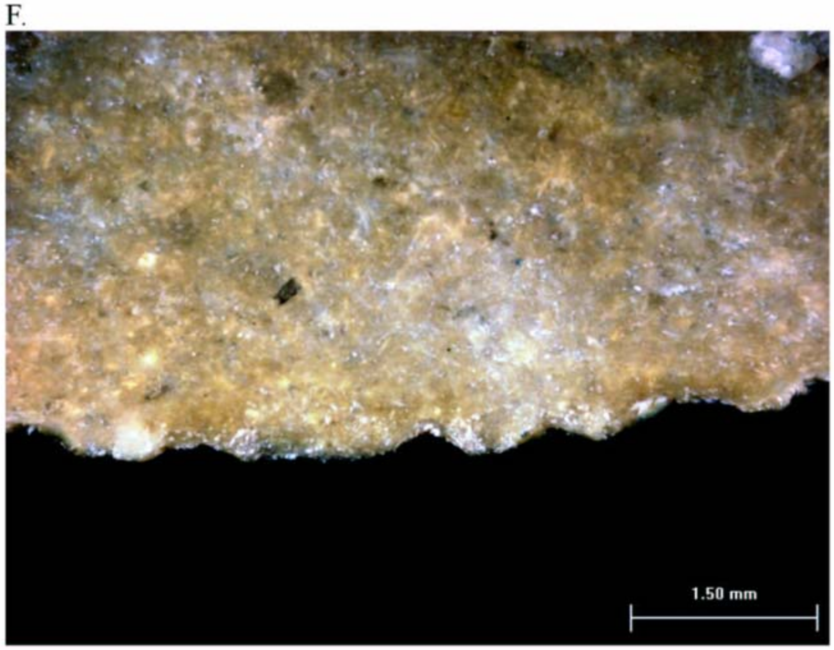
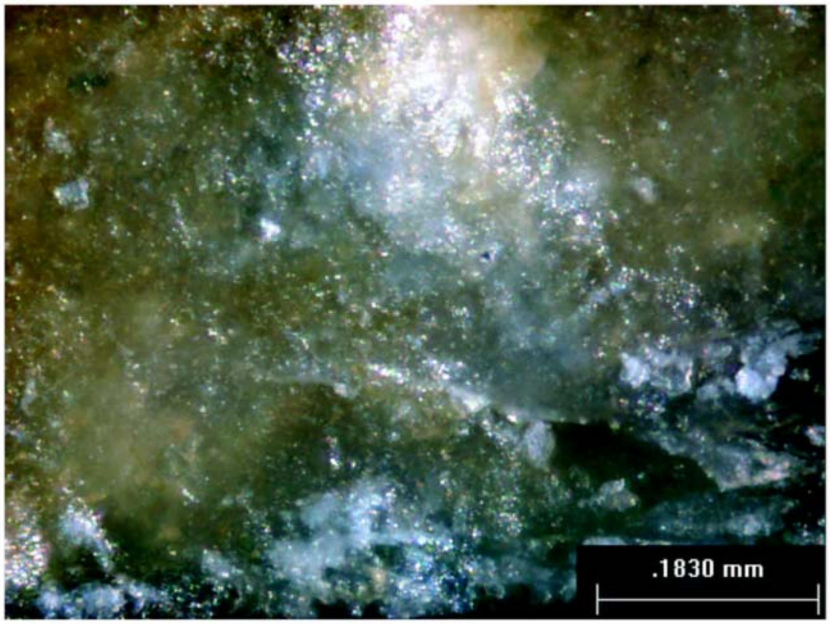


Plate 14, continued. E) Polish at left lateral edge at 160x.
F) Alternate flaking at the right lateral edge at 16x.

G.



H.

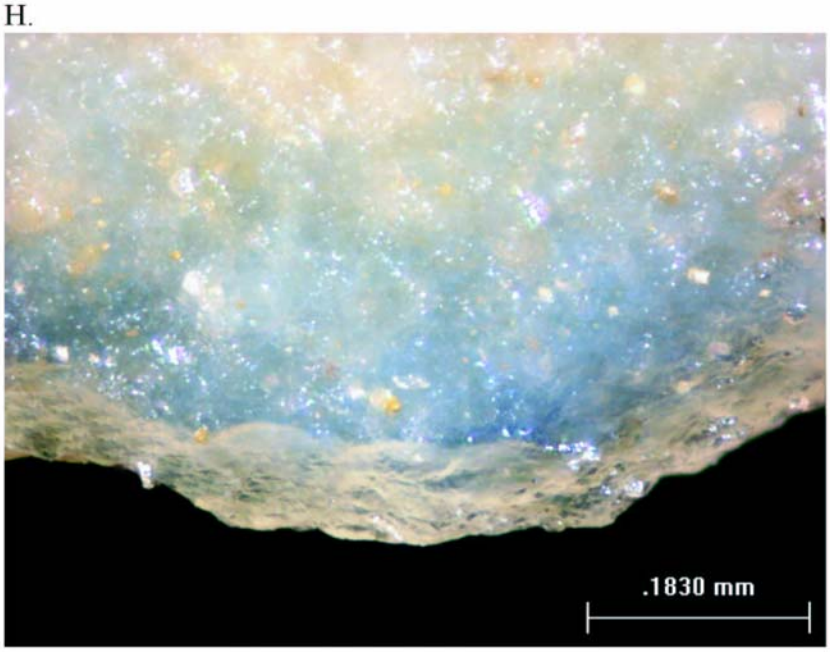
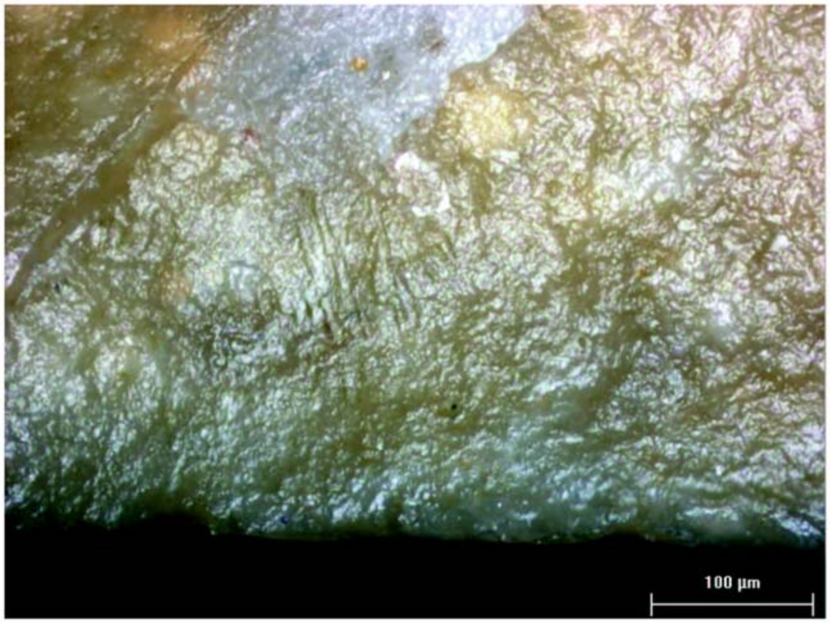


Plate 14, continued. G) Right lateral edge near the distal end of the tool at 160x. H) Right lateral edge on the ventral surface of the tool at 150x.

I.



J.

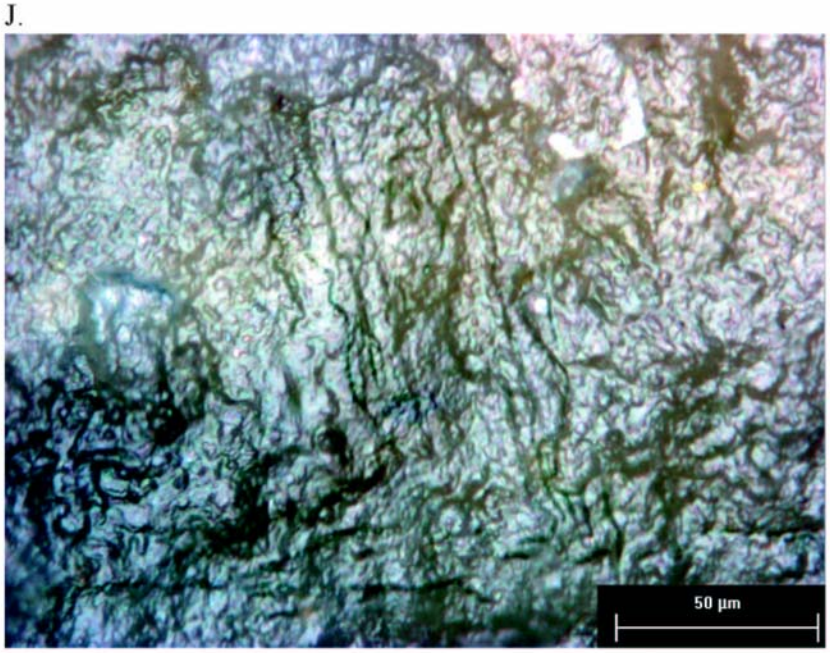
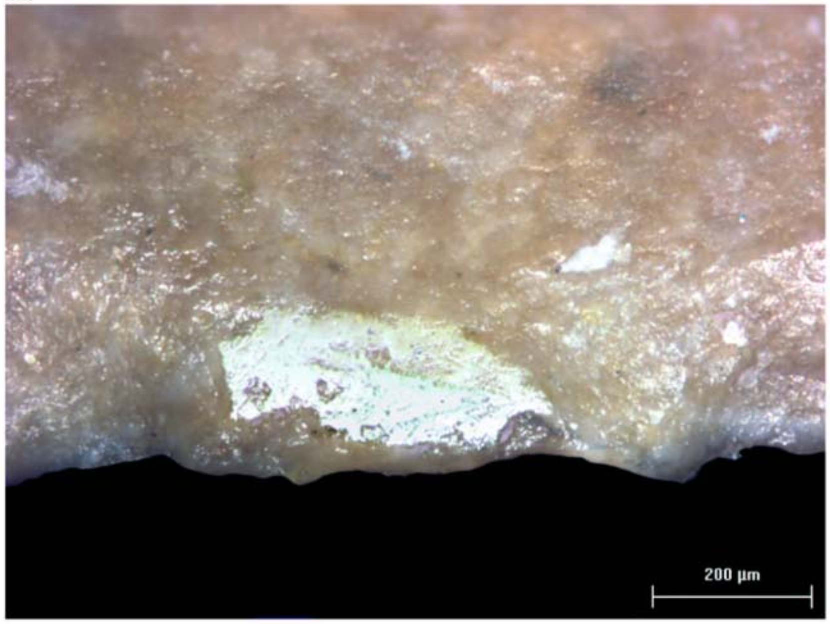


Plate 14, continued. I) The right lateral edge on the dorsal face at 200x.
J) The same feature at 500x.

K.



L.

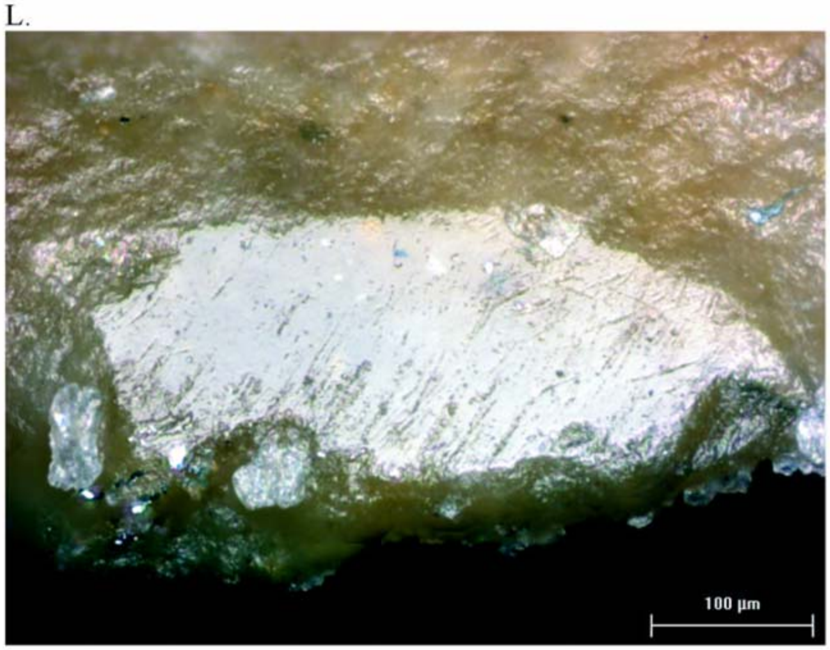


Plate 14, continued. K) Right lateral edge, dorsal surface at 100x.
L) The same feature at 200x.

M.

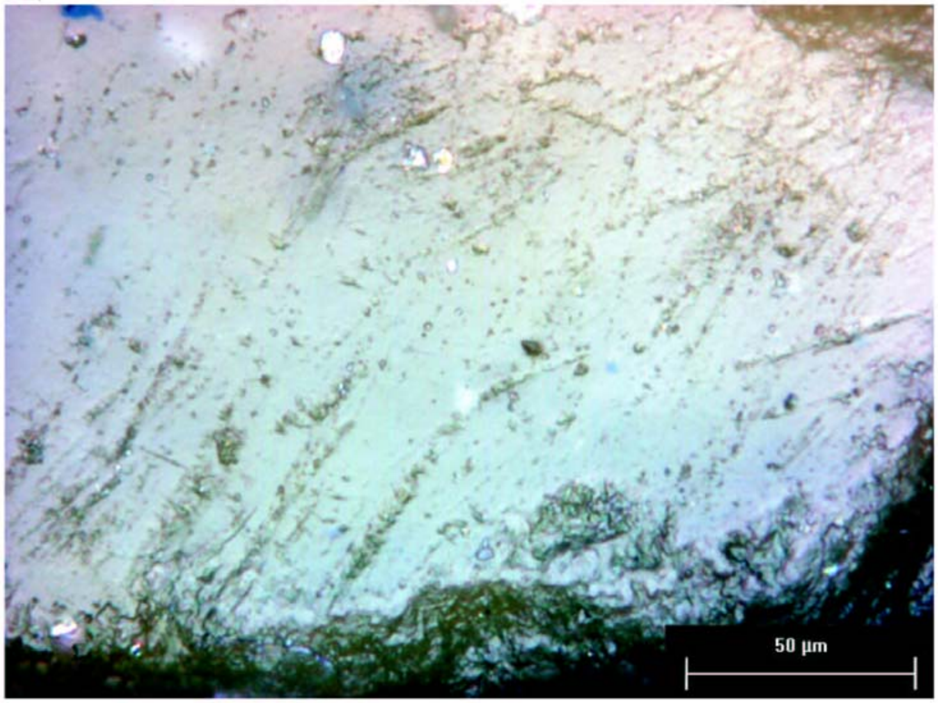


Plate 14, continued. M) The same feature depicted in K and L shown here at 500x.

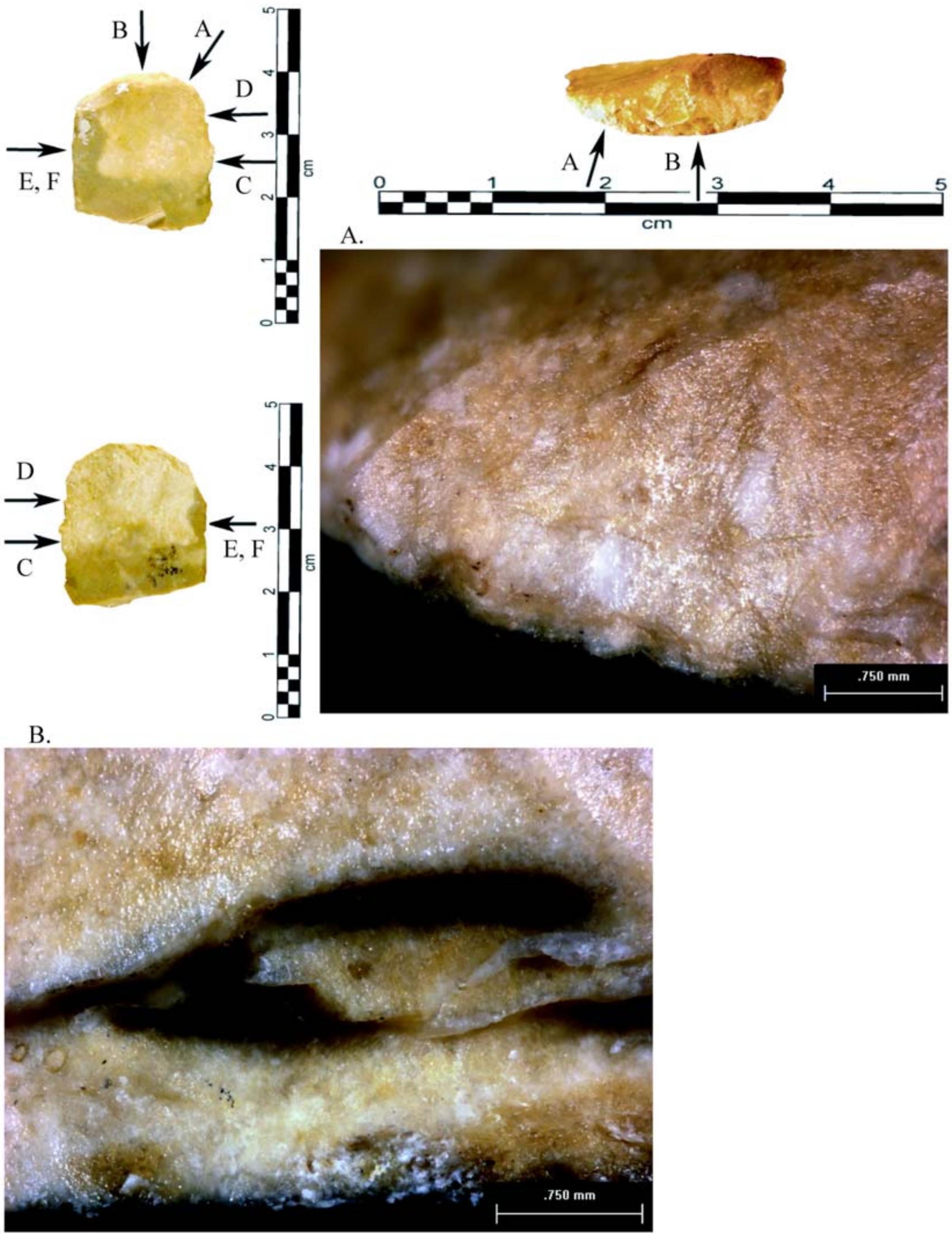


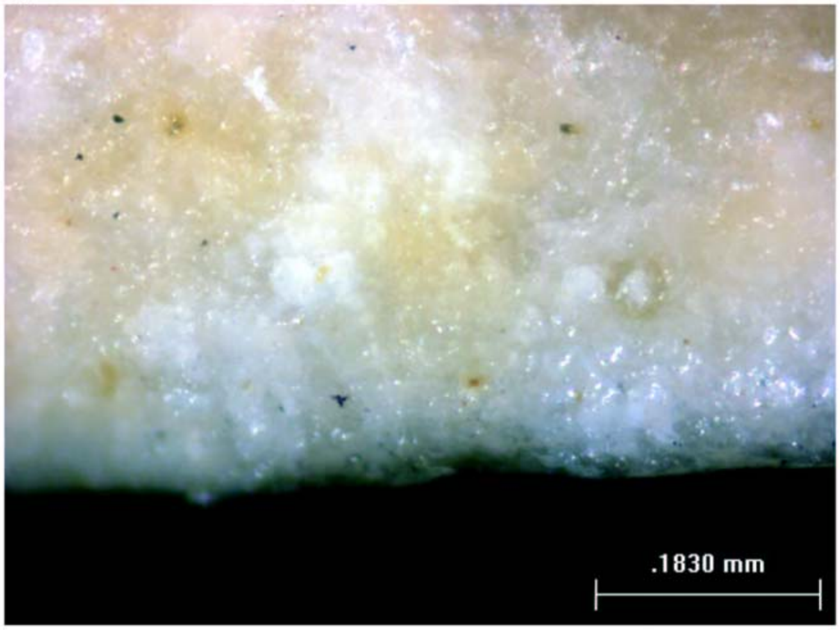
Plate 15. G299 use-wear images. A) Right side of the bit edge at 25x.
B) Center of the bit edge at 32x.

C.

D.

Plate 15, continued. C) Right lateral edge at 20x. D) Right lateral edge proximal to the area shown in C at 50x.

E.



F.

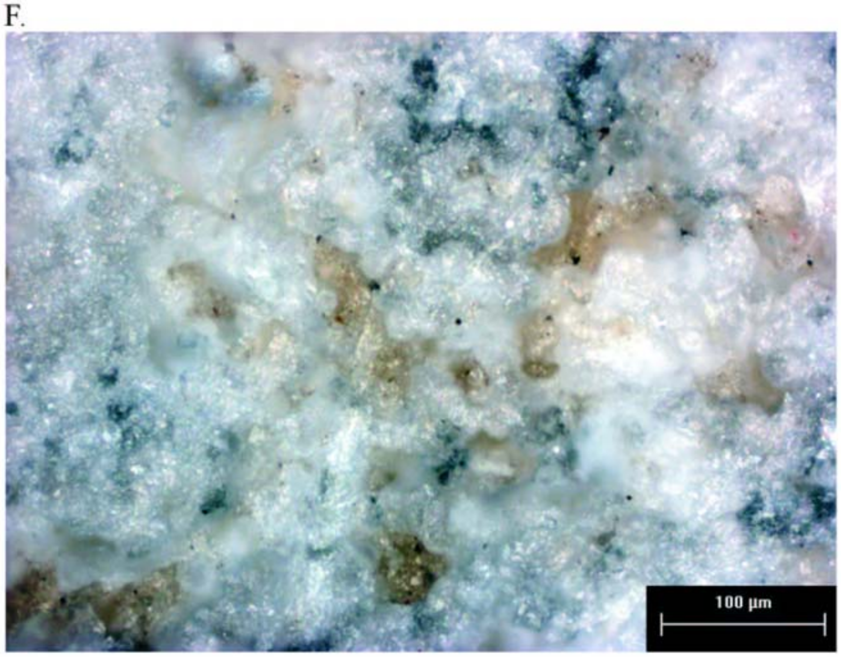


Plate 15, continued. E) Ventral edge at left lateral snap fracture at 160x.
F) Deposit on the ventral surface at the left lateral snap fracture at 200x.

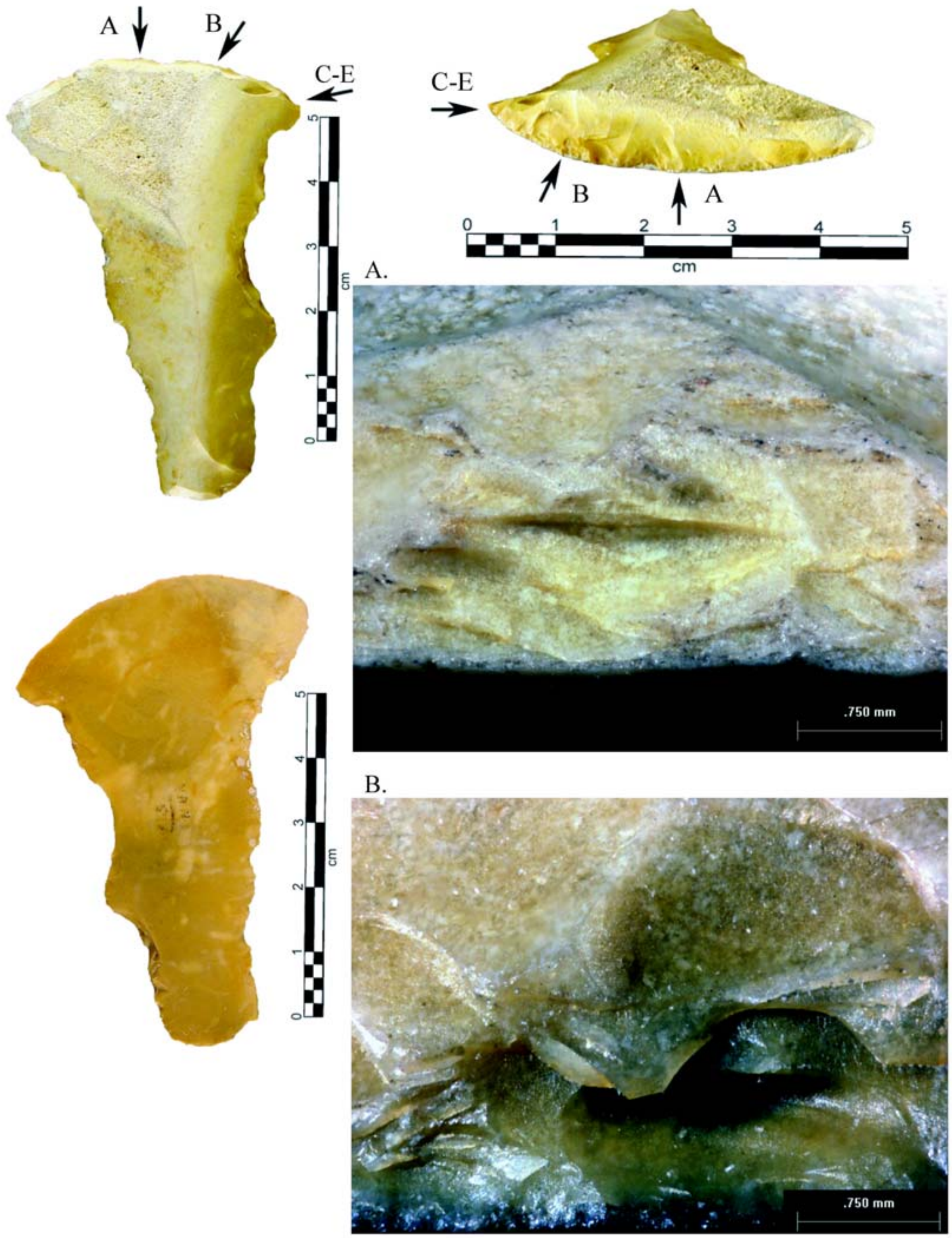
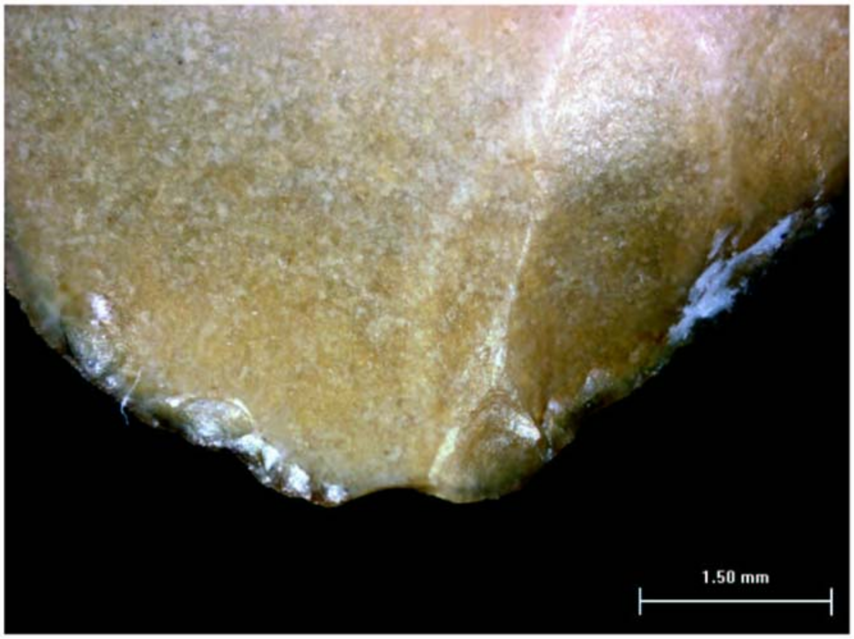


Plate 16. G301NNN use-wear images. A) Center of the bit edge at 32x.
B) Bit edge to the right of center at 32x.

C.



D.

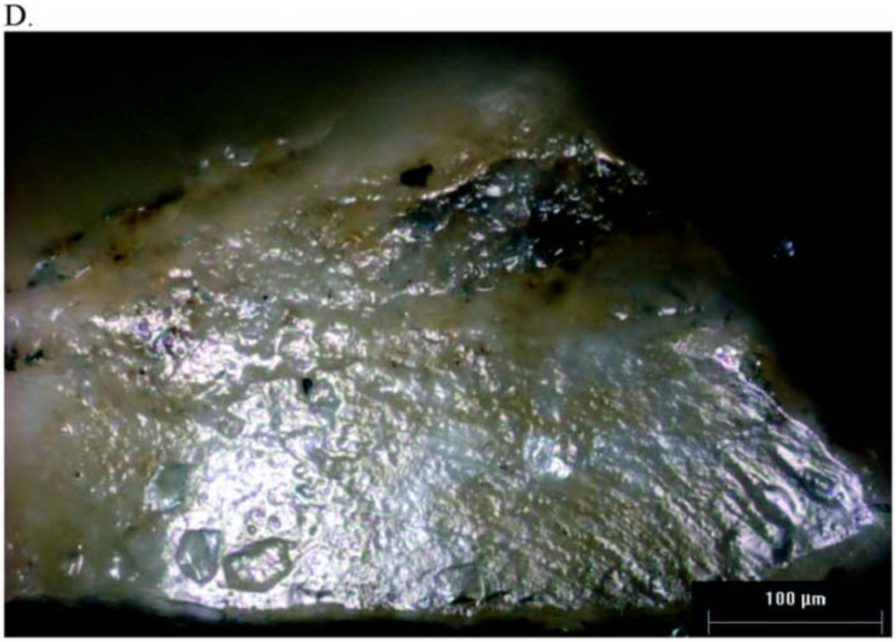
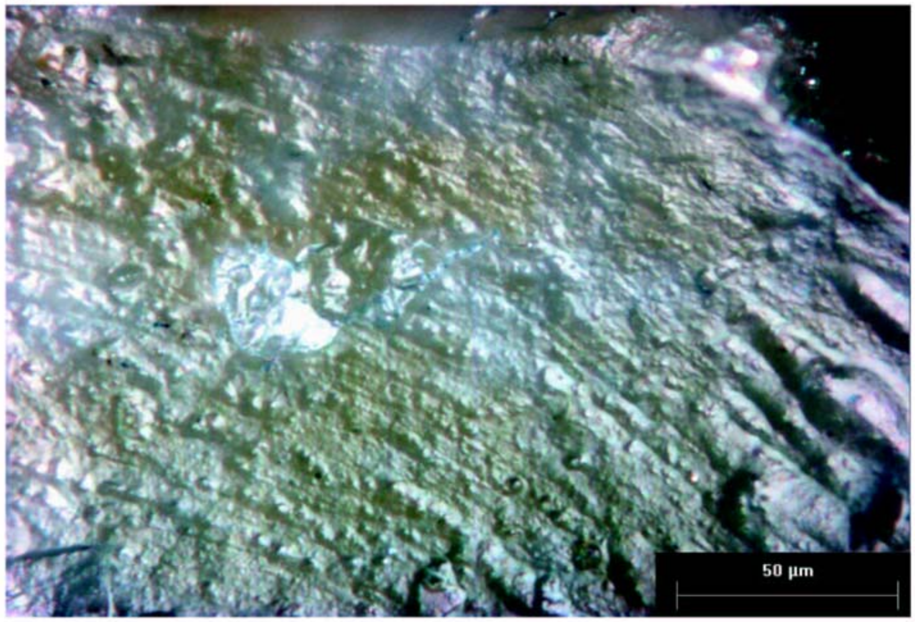


Plate 16, continued. C) Dorsal view of the right spur tip at 16x.
D) End-on view of the right spur tip at 200x.

E.



F.

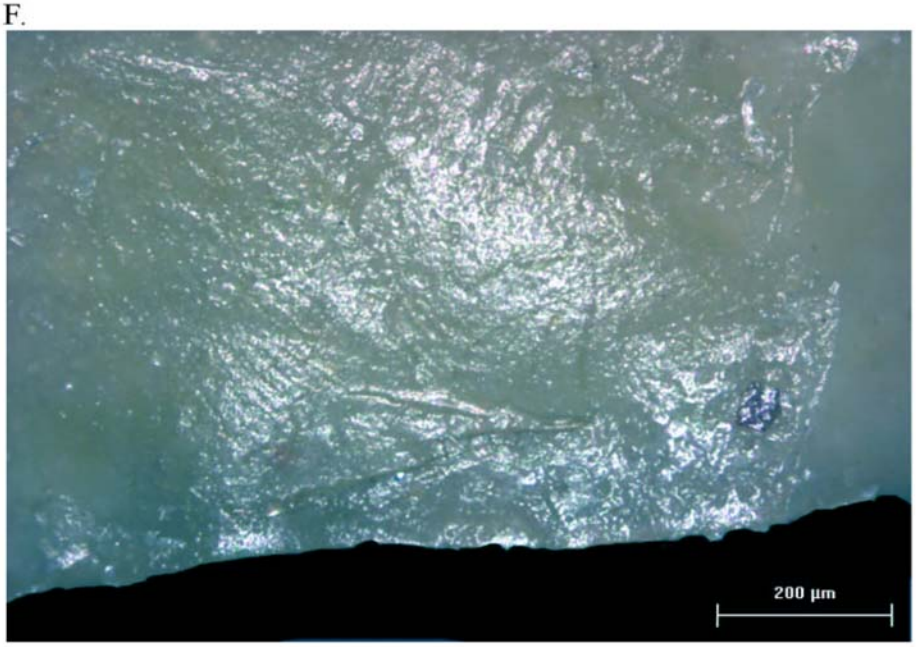


Plate 16, continued. E) Right spur tip as in D, shown here at 500x.
E) Right lateral edge at 100x.

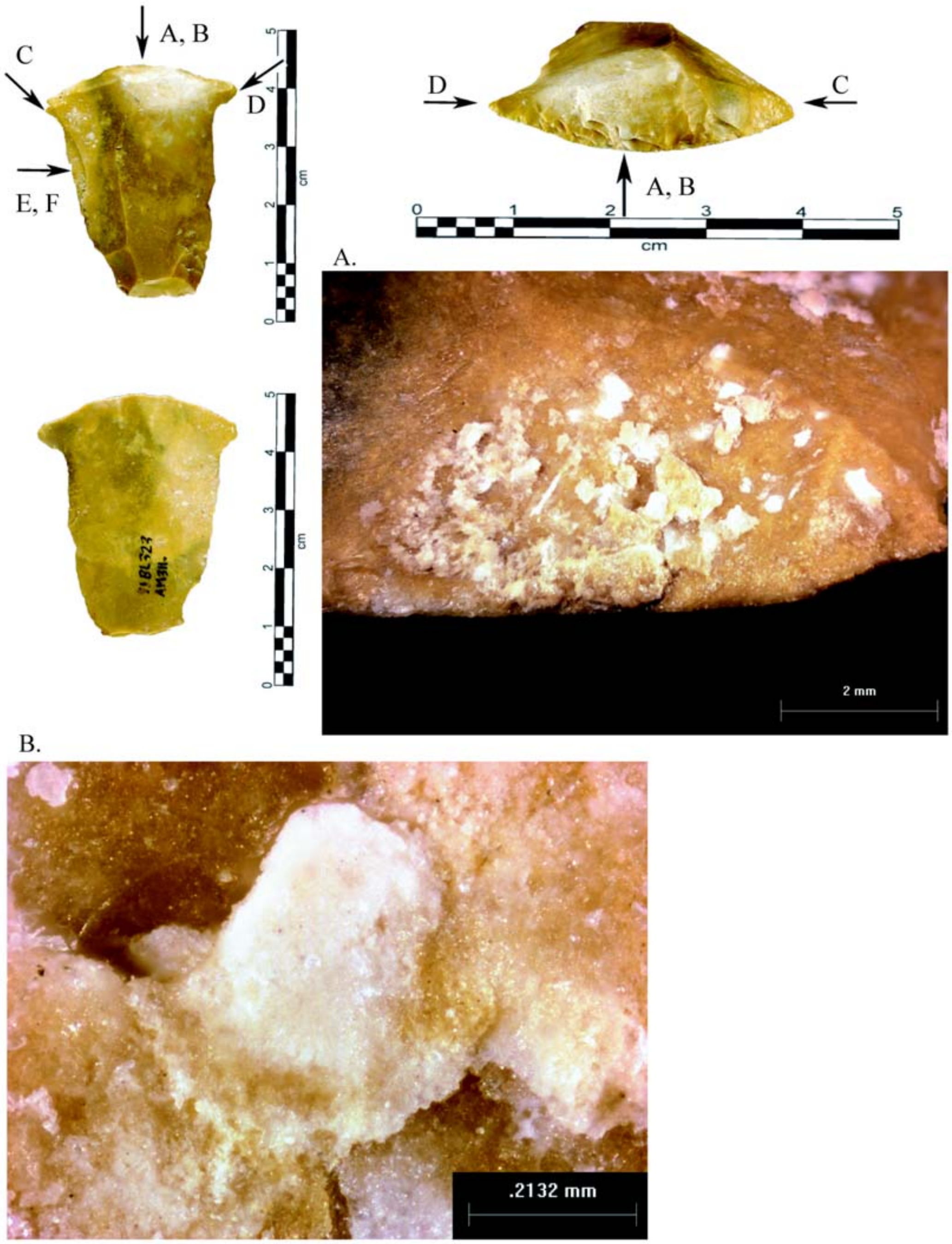
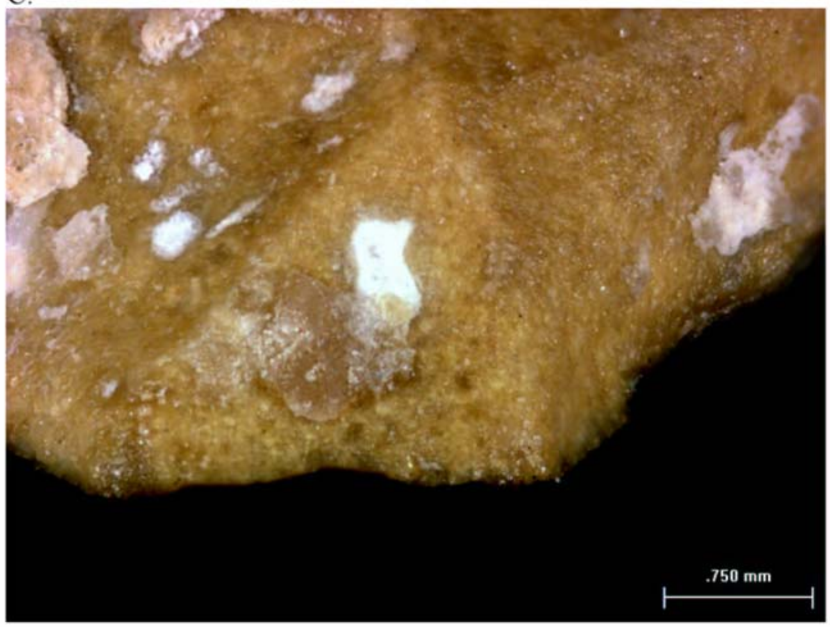


Plate 17. G3111 use-wear images. A) Deposits on the bit edge at 12x.
B) The same feature at 128x.

C.



D.

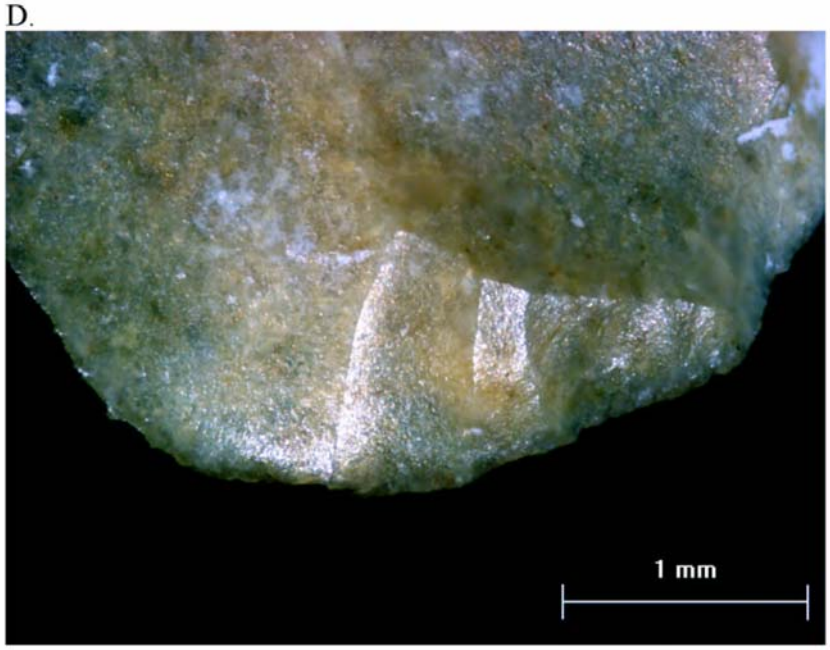


Plate 17, continued. C) Dorsal view of the left spur tip at 25x. D) Dorsal view of the right spur tip at 32x.

E.

F.

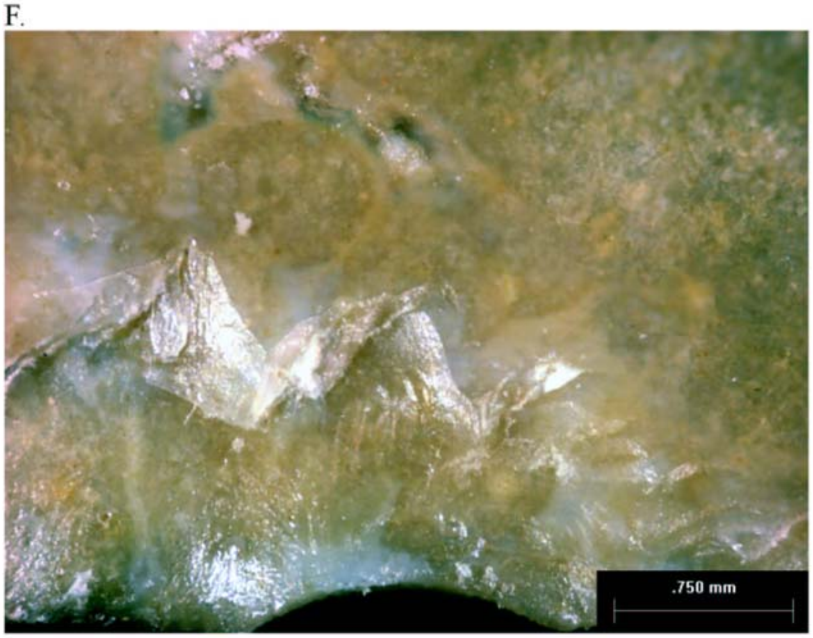


Plate 17, continued. E) A sequence of step fracture terminations on the left lateral edge at 30x. F) The image shows the sequence of scars continuing along left lateral edge toward the proximal end of the tool, also at 30x.

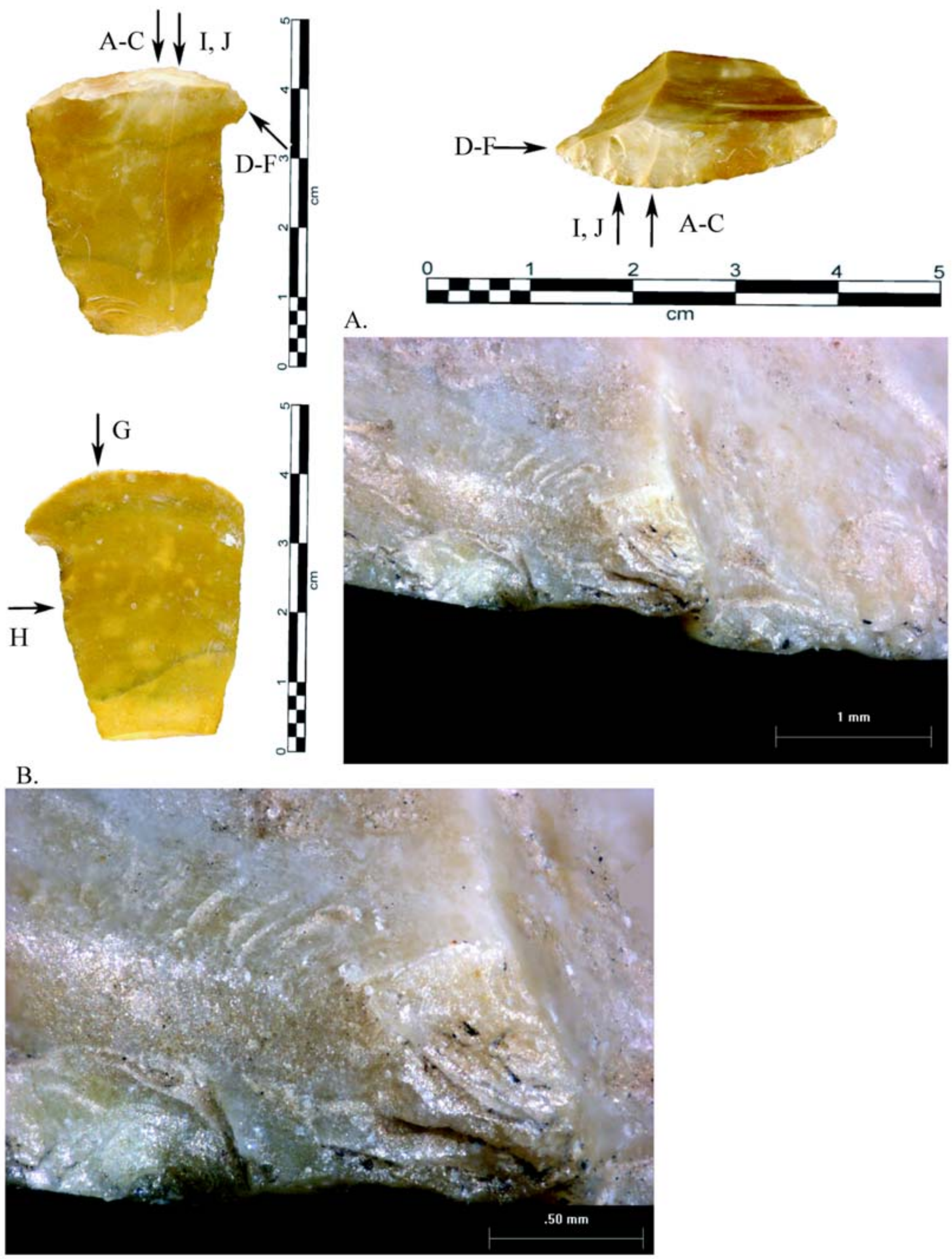
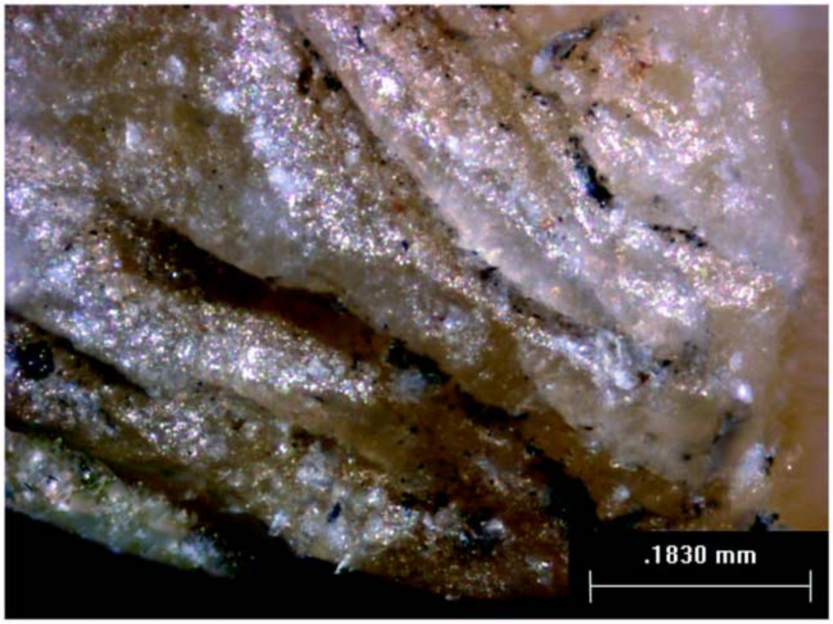


Plate 18. G319 use-wear images. A) Center of the bit edge at 25x.
B) The left half of A at 50x.

C.



D.

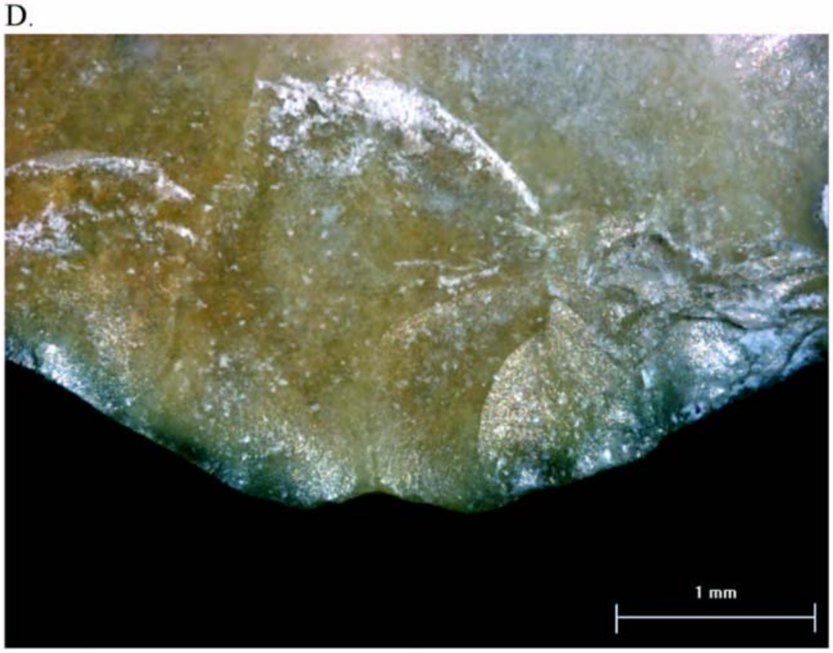
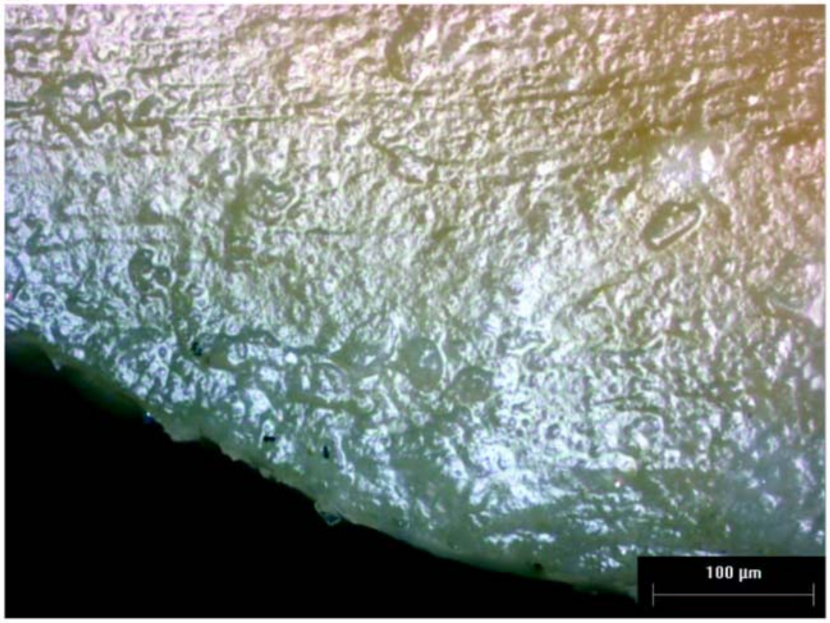


Plate 18, continued. C) The same sequence of step scars depicted in A and B, shown here at 145x. D) Dorsal view of the spur tip at 25x.

E.



F.

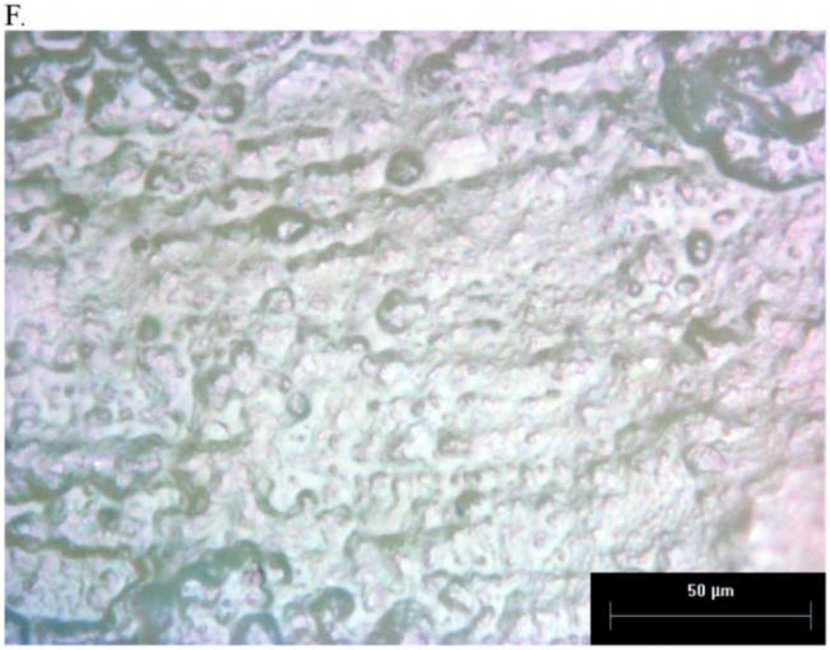
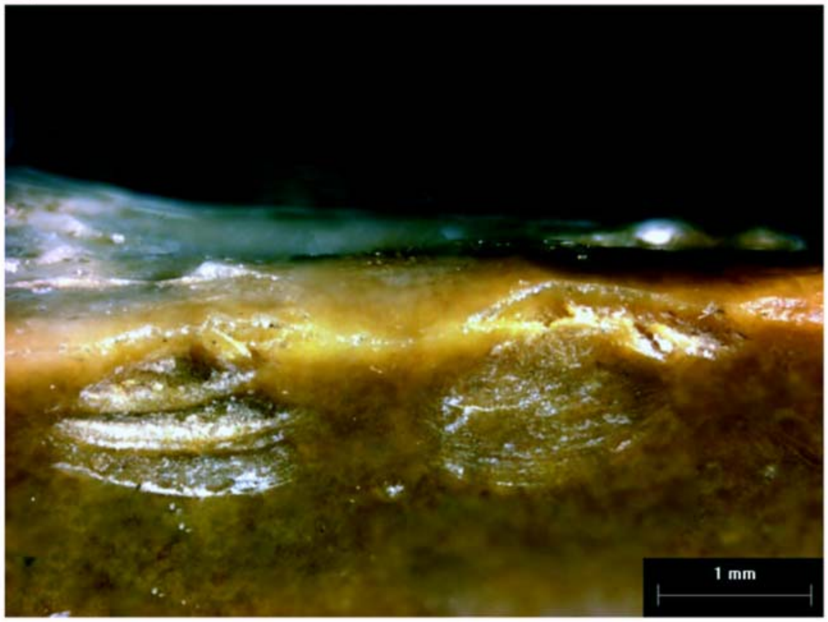


Plate 18, continued. E) Spur tip at 200x showing linear indicators and a color and texture change along the edge. F) The same feature at 500x.

G.



H.

Plate 18, continued. G) Ventral edge damage at bit at 20x. H) Left lateral edge wear, dorsal surface at 100x.

I.

J.

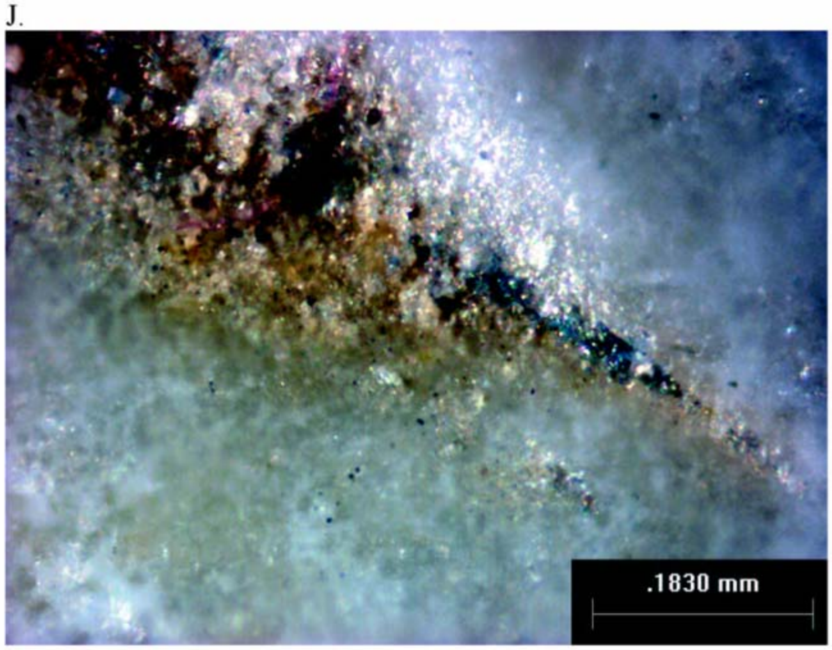


Plate 18, continued. I) Worn step scar on the dorsal face of the bit overlaid with surface deposition at 64x. J) Right-hand portion of the same feature at 160x.

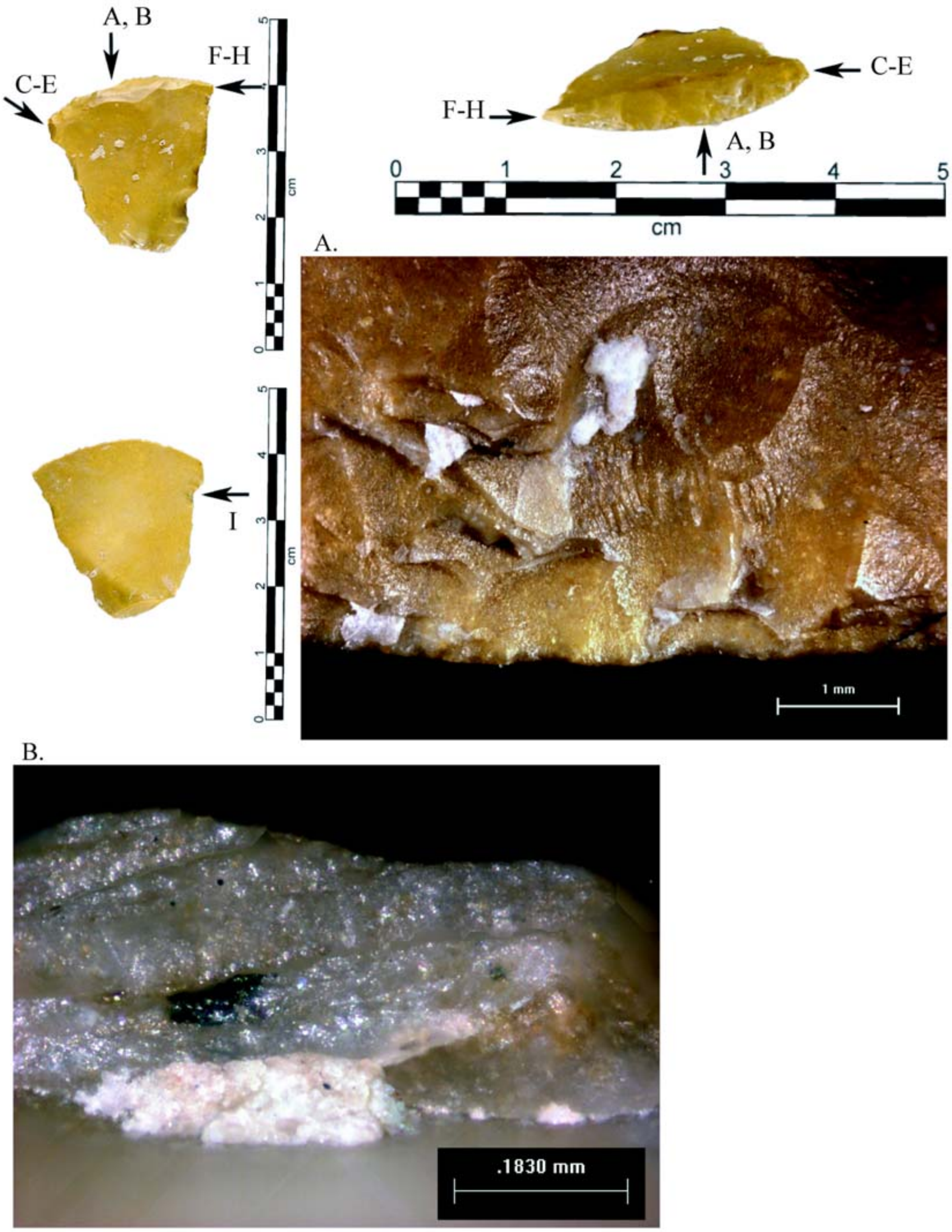


Plate 19. G364 use-wear images. A) Bit edge just to the left of center at 20x. B) Worn step fracture scars viewed parallel to the dorsal tool surface near the bit edge at 190x.

C.

D.

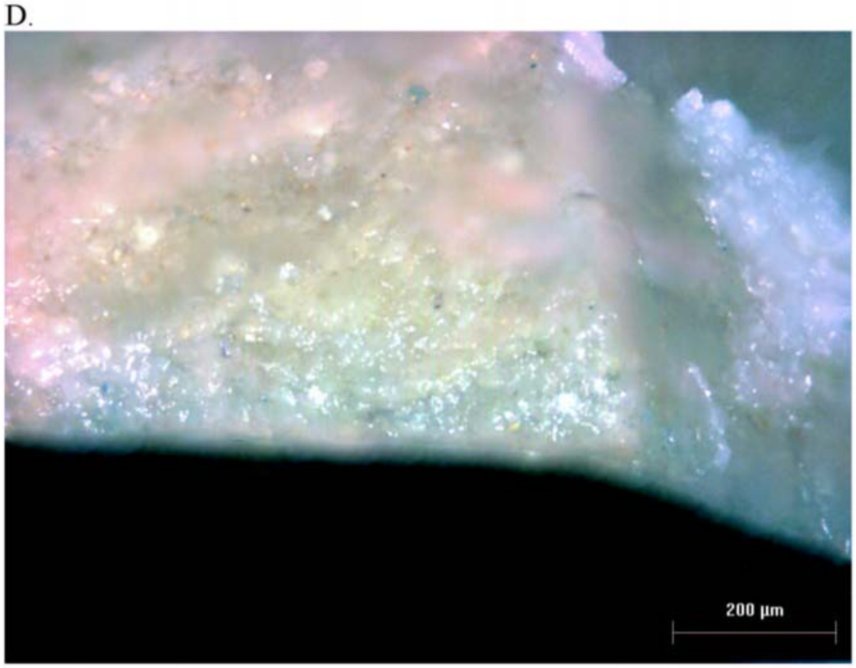
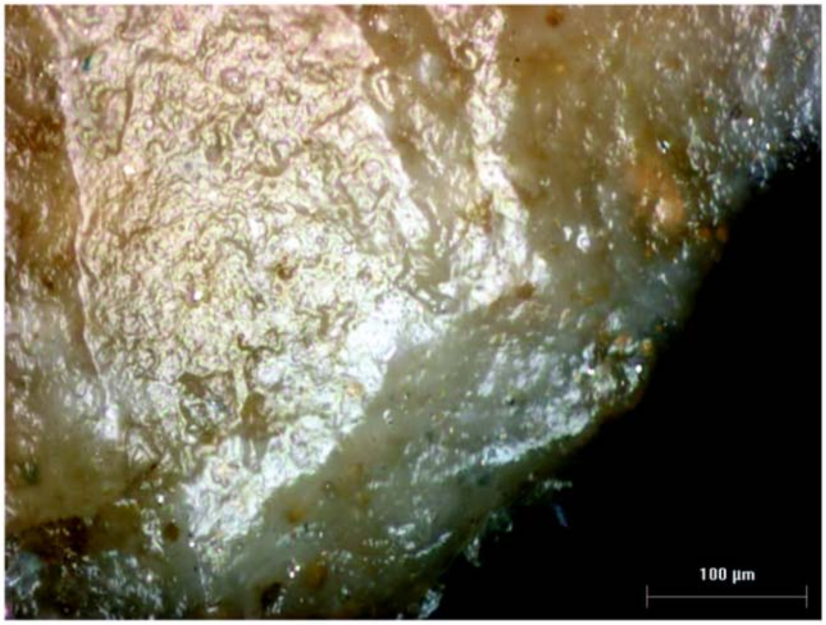


Plate 19, continued. C) Dorsal view of the left spur at 25x.
D) End-on view of the left spur/bit junction at 100x.

E.



F.

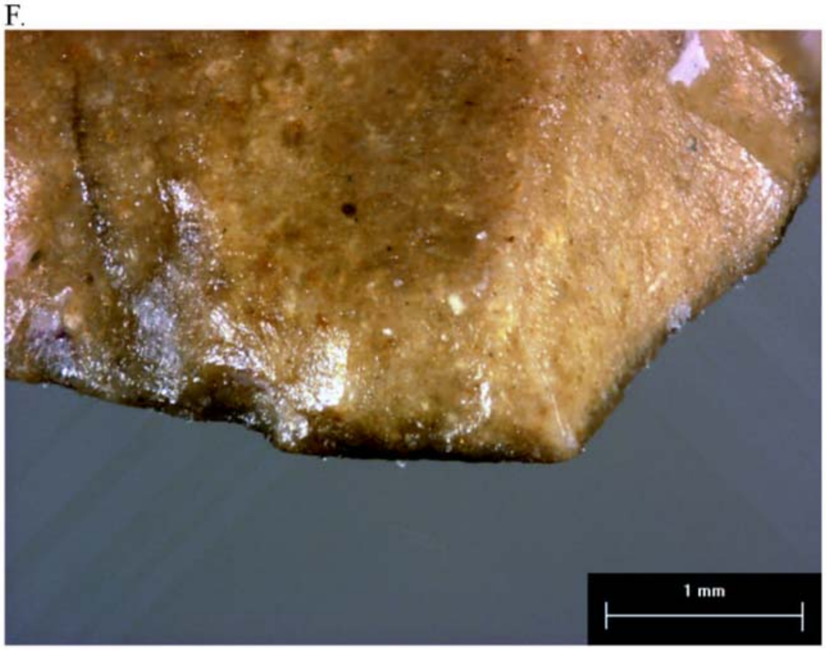
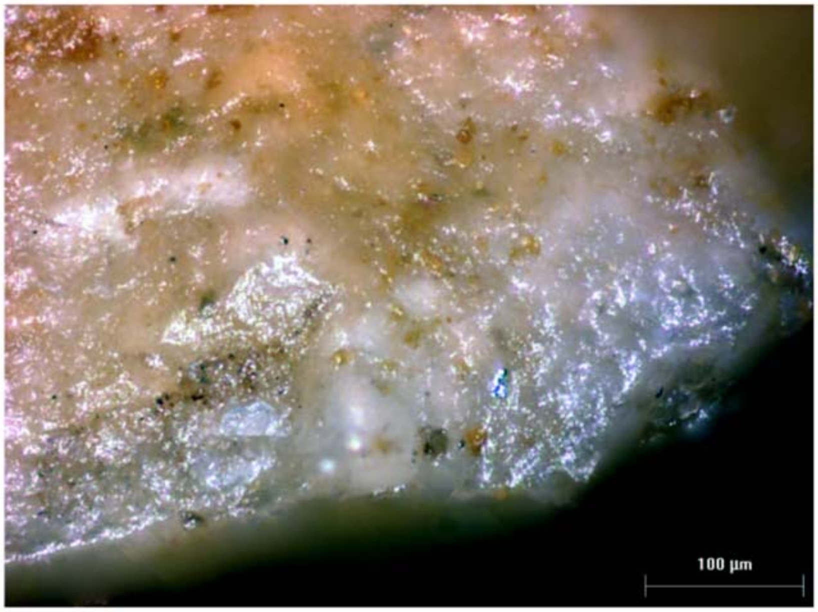


Plate 19, continued. E) Dorsal view of the posterior portion of the left spur at 200x. Beginning of the notch is at upper right. F) Dorsal view of the right spur at 25x.

G.



H.

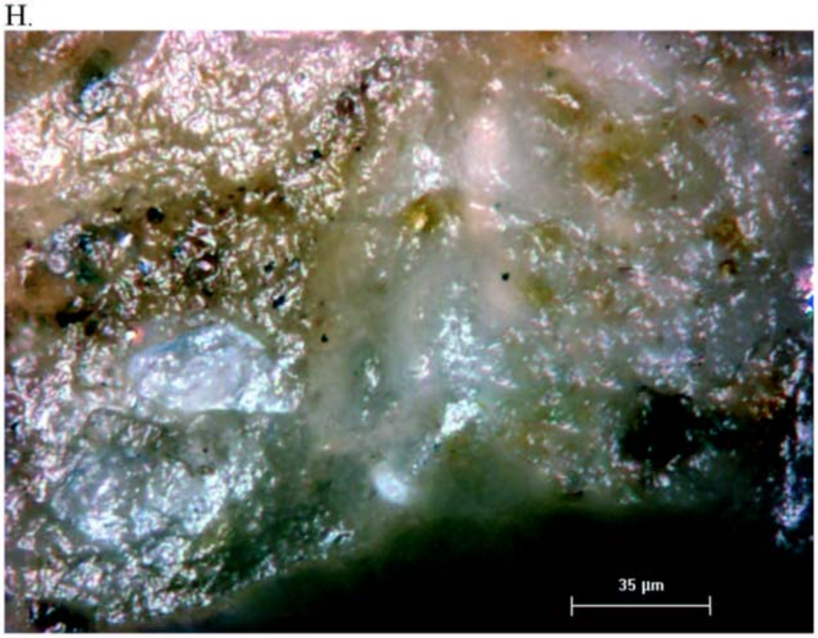
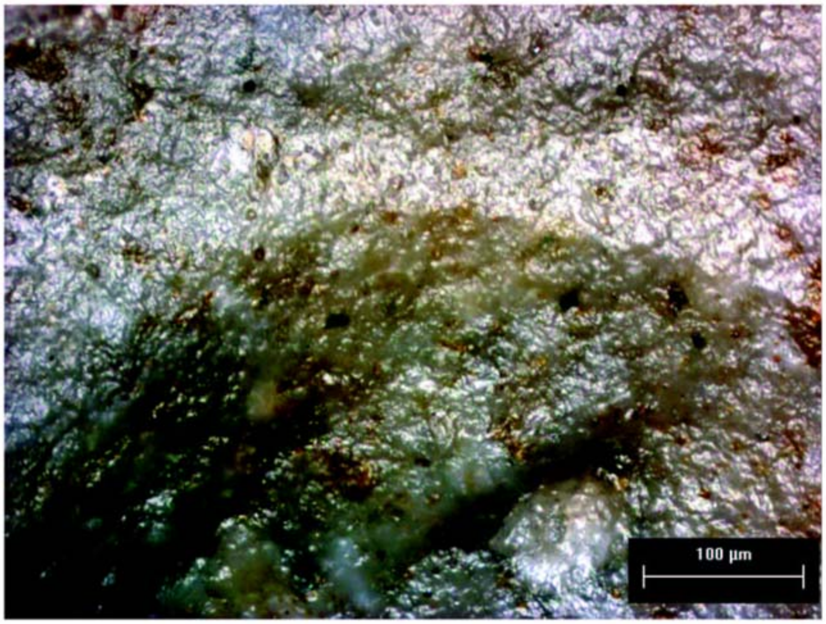


Plate 19, continued. G) Prominence on right spur tip at 200x.
H) The same feature at 500x.

I.



J.

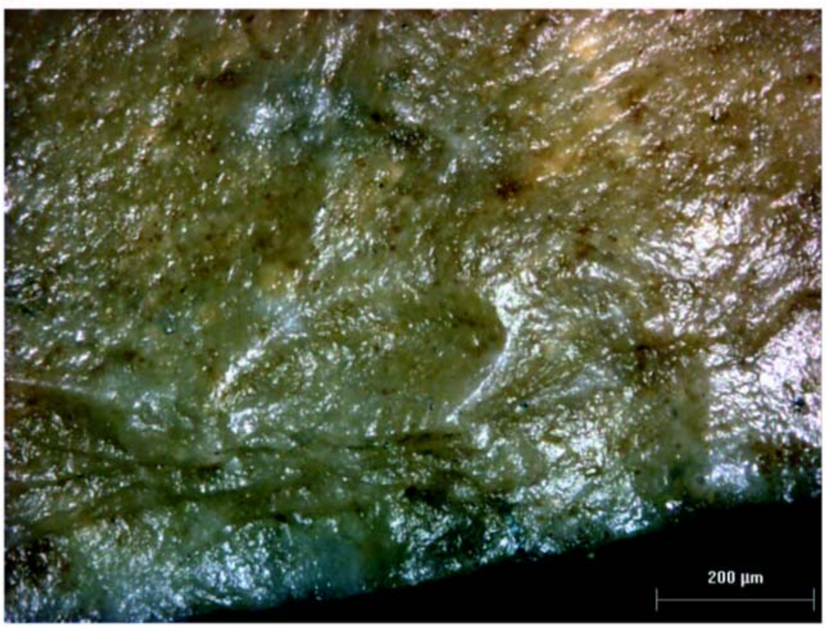


Plate 19, continued. I) View of the left ventral at the junction of the spur and lateral edge at 200x. J) Left spur tip at 100x.

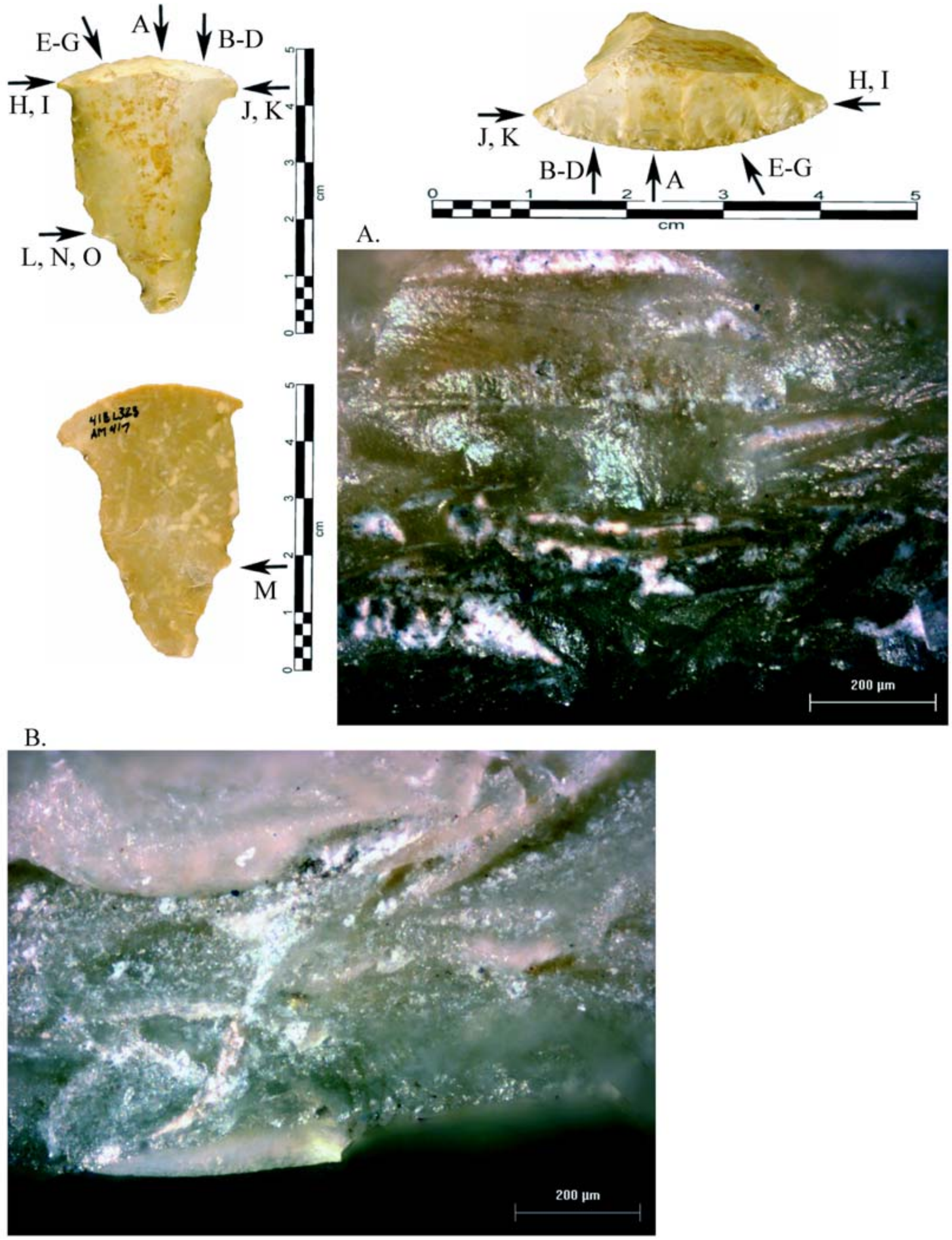
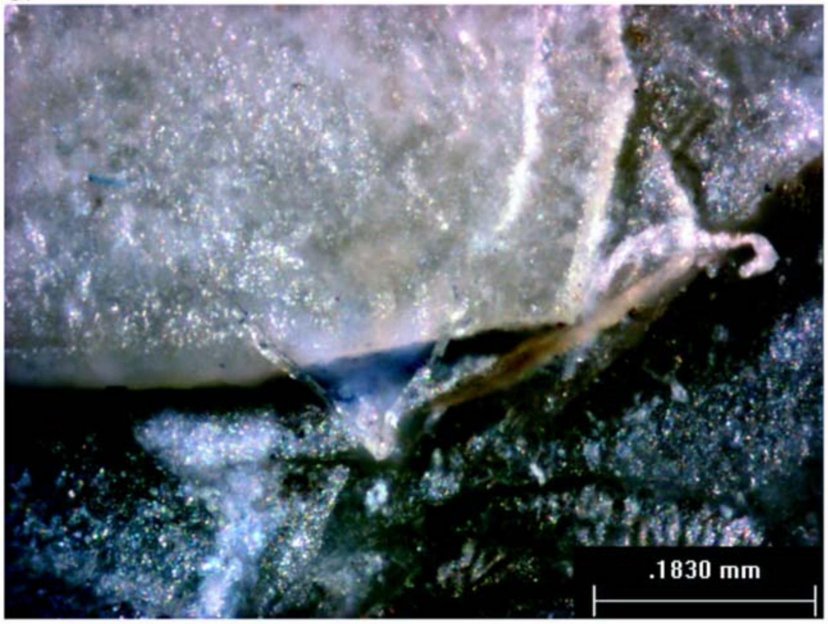


Plate 20. G417 use-wear images. A) End-on view of a series of step scars that have undercut the center of the bit edge at 100x. B) End-on view of the a step scar to the right of the center of the bit, looking across the surface of the edge at 100x.

C.



D.

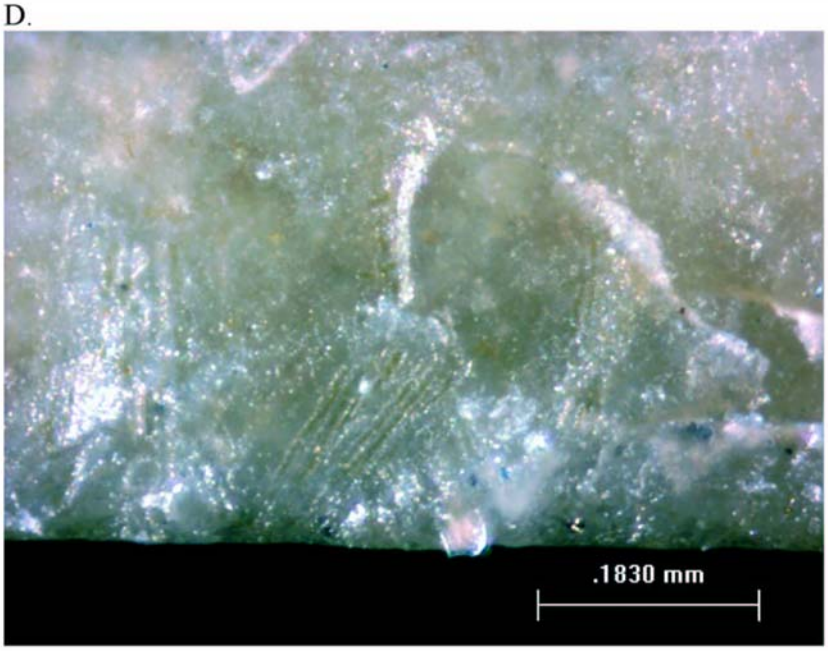


Plate 20, continued. C) Another view of the feature in B shown at a different angle and at 160x. D) Slightly further to the left of the center of the bit edge at 160x.

E.

F.

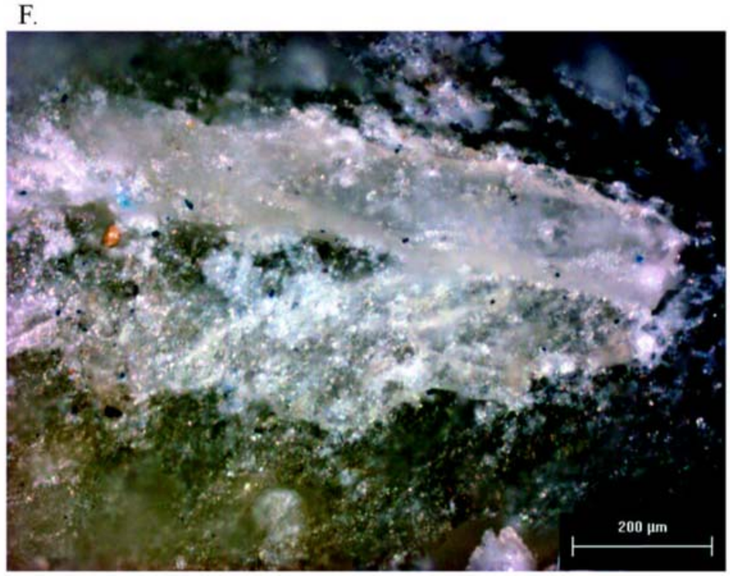
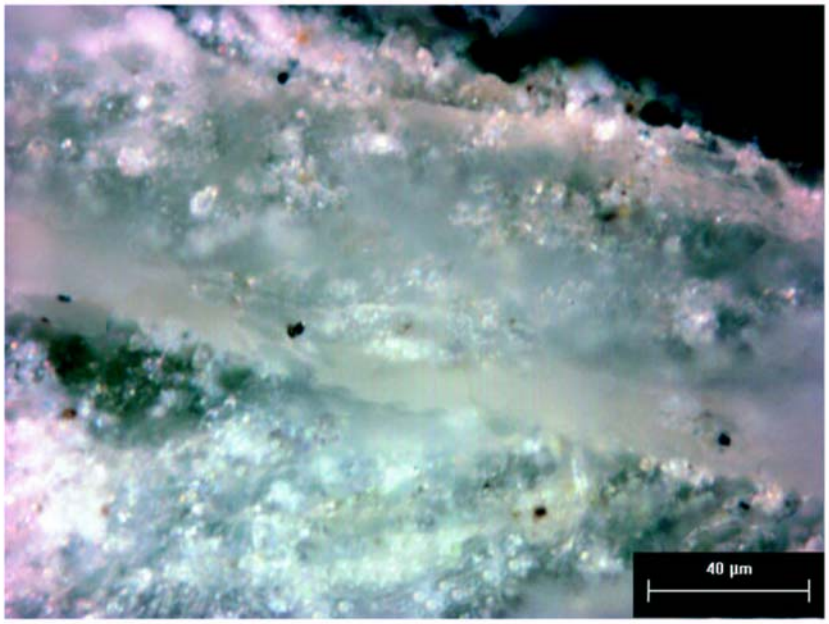


Plate 20, continued. E) Depositional “streak” parallel to the bit edge at 100x. The bit edge is at the very bottom of the image. F) The same feature at 200x.

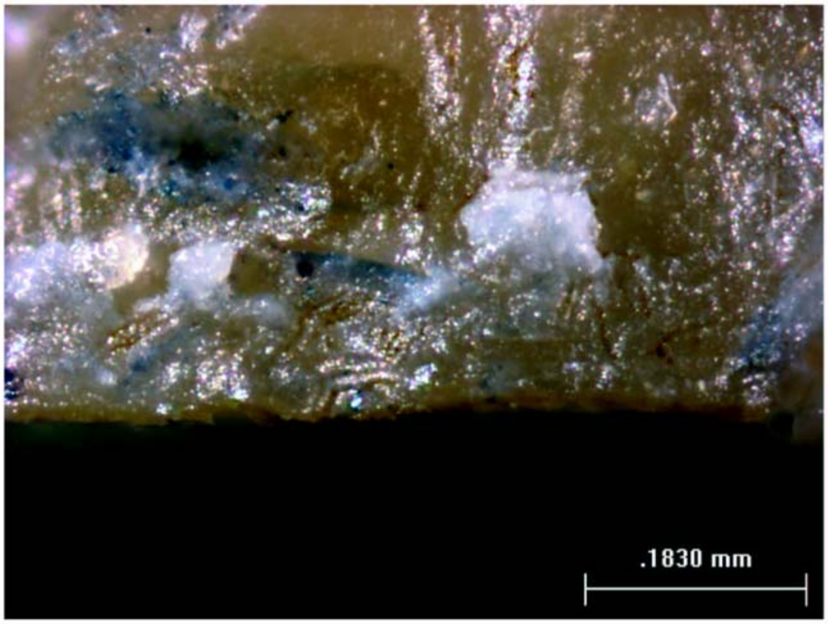
G.



H.

Plate 20, continued. G) The same feature as in E and F, shown here at 500x.
H) Dorsal view of the left spur tip at 25x.

I.



J.

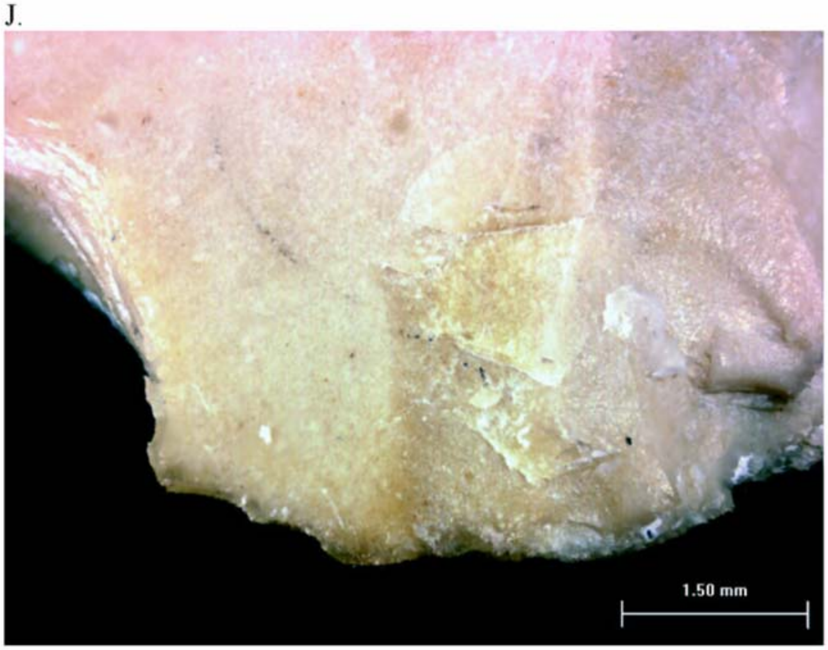
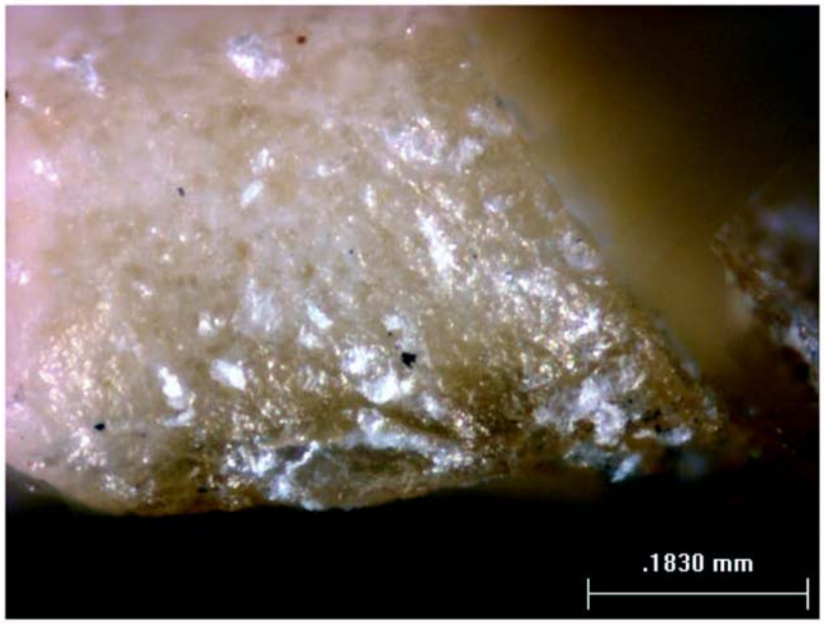


Plate 20, continued. I) Facing the left spur tip at 160x.
J) Dorsal view of the right spur tip at 16x.

K.



L.

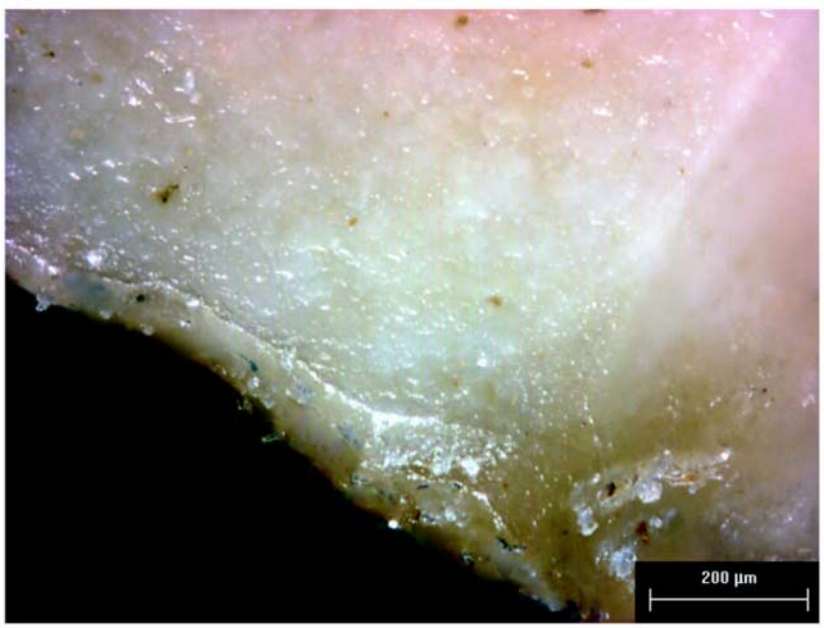
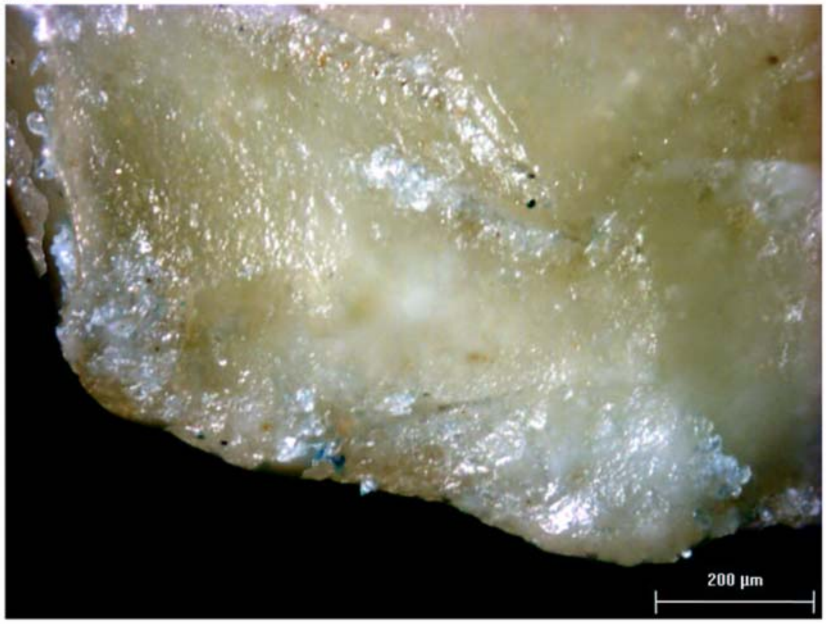


Plate 20, continued. K) The right spur tip at 160x. L) Dorsal view of a projection on the left lateral edge at 100x.

M.



N.

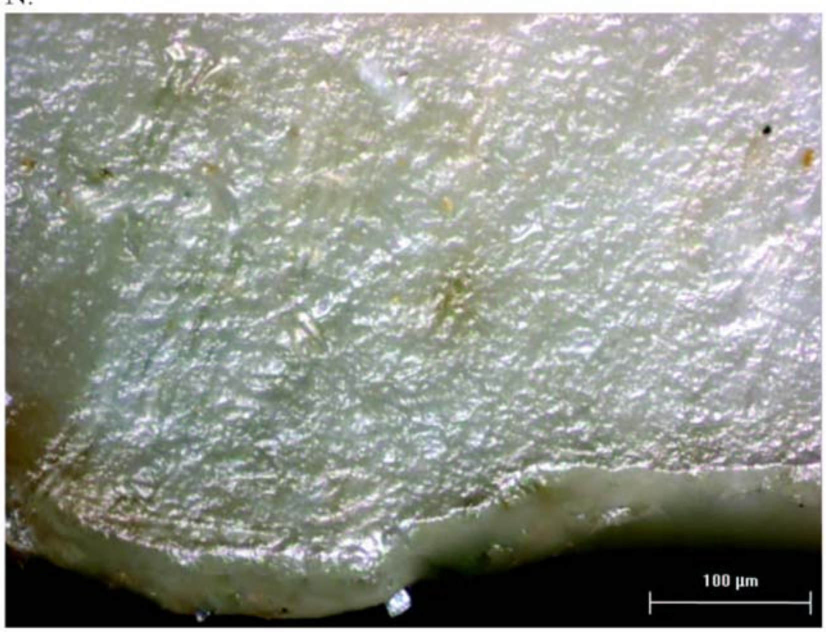


Plate 20, continued. M) Ventral view of the left lateral projection shown in L, also at 100x. N) Dorsal view of the same feature at 200x.

O.

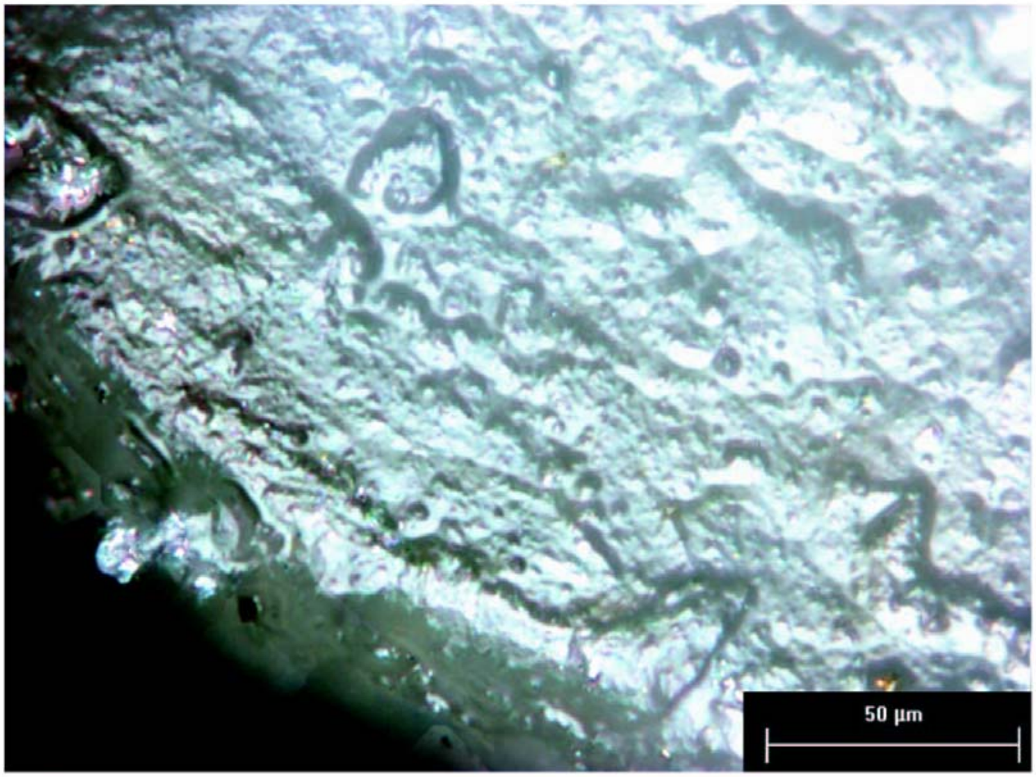


Plate 20, continued. O) The same feature as in N, shown nere at 500x.

VITA

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Degrees: M.A. in anthropology, May 2004
B.S. in animal science, December 1975

Publications:

2004 The Presence and Absence of Bison in the Post Oak Savannah. *Bulletin of the Texas Archeological Society* (In press).

2004 A Study of Two Ancient Bows from Southwest Texas. *Bulletin of the Texas Archeological Society* (In press).

Field Schools:

Summer 2001 - field school teaching assistant at Gault site
Spring 2000 - field school student at Gault site
Spring 1996 - field school student at Yeagua creek and Keechi creek survey

Interests: My interests lie in functional studies of stone tools used on various materials. My thesis work was a functional analysis of hide scrapers, primarily because I have years of practical experience processing hides. In these years, I have tried to maintain a strong analog between my work and what is known of ancient hide work. I became interested in the microscopic analysis use-wear while working with Dr. Harry Shafer in 1997 at Texas A&M University. I gained further experience in microwear analysis at the Texas Archeological Research Lab in Austin, working with Dr. Dale Hudler during 1998-2001. For the past year, I have worked under the direction of Dr. Robson Bonnichsen in the micro-imaging lab at the Center for the Study of the First Americans, conducting use-wear studies on material from several sites including Gault, Topper, and Pedra Ferrada.